Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

Journal of the Society of Arts.

FRIDAY, MAY 7, 1858.

THE SOCIETY'S CONVERSAZIONE AT THE SOUTH KENSINGTON MUSEUM.

Members are requested to take notice that the next Conversazione will be held at the South Kensington Museum, on Saturday (to-morrow) the 8th of May. The doors will be opened at 8 o'clock.

The following divisions of the Museum will be lighted on this occasion:—

1. The Sheepshanks Gallery of Pictures.
2. The Sculpture Gallery.
3. The Architectural Museum.
4. The Animal Produce Collections.
5. The Ornamental Art Collections.
6. The Structure and Building Materials Collections.
7. The Educational Collections.
8. The Collection of Patented Inventions.
9. The Photographic Society's Exhibition.
10. The Art Training Schools.

The following objects will be exhibited to the public for the first time:—

1. A Model, showing the Campaign before Sebastopol, executed by Col. Hamilton, C.B., Grenadier Guards, at the suggestion of his Royal Highness the Prince Consort, for the United Service Institution.

2. Statue of Venus, by J. Gibson, R.A., and the picture of the "Duchess of Burgundy distributing Alms," by Leys (the celebrated Belgian artist), will be lent by Matthew Uzielli, Esq., a member of the Society.

Carriages are to set down at the refreshment entrance. The band of the 1st Life Guards will be in attendance.

TENTH ANNUAL EXHIBITION OF INVENTIONS.

The number of visitors up to yesterday, the 6th inst., was 4,342.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 5, 1858.

The Twenty-First Ordinary Meeting of the One Hundred and Fourth Session was held on Wednesday, the 5th inst., Sir Thomas Phillips, Member of the Council, in the chair.

The following Candidates were balloted for and duly elected members of the Society:—

Edgar, George | Lane, Edward
Raynham, Viscount, M.P.

The Paper read was—

IRON: ITS COMMERCE AND APPLICATION TO STAPLE MANUFACTURES.

BY CHARLES SANDERSON.

The importance of the manufacture of iron, as a metal required for the various wants of mankind, has called forth the energies of the chemist and the mechanic. It is not found in a metallic state. Nature has mixed the ores of this metal with a vast variety of substances, from which it is necessary to separate them, before they are servicable for useful purposes.

The ores principally used for the production of iron are before you: the black oxides, being generally a mixture of the per and protoxide; the peroxides, which embrace many varieties, as hæmatites, hydrates, &c.; the sparry carbonates, or steel ore; and the earthy carbonates, which are so largely found associated in the coal basin.

It is not necessary for me to give you any detailed account of the localities of these minerals, because this has been recently laid before you, and their geological position has been fully treated. I may briefly remark, that the black oxides and hæmatites, being very rich in metal, are principally smelted with charcoal as a fuel, whilst the earthy carbonates are reduced with coke or coal.

The period at which iron was first produced is lost in the most remote antiquity. At present, it would consume too much time, were I to trace the progress which has been made, from the earliest known mode of production up to the colossal means now employed. Possibly it might be a very interesting investigation, but is certainly not necessary to our present inquiry.

Metallurgy is a science of vast extent in its application, and in its practice draws largely upon the researches of the chemist and the mechanic. Whilst geology and mineralogy direct the inquirer where he may hope to discover the hidden treasures of the earth, they shed a light upon that information which leads to a knowledge of their position, and the state in which they are found; chemistry enables the metallurgist to ascertain both the quantity and the quality of those substances which nature has mixed up with the metal, and it opens a wide and interesting field of investigation, in what manner the metal may be obtained in a useful state, at the lowest possible cost; and mechanical knowledge lends its aid, in the construction of those machines which are required, not only to enable the miner to obtain the ore and fuel, but also to reduce the cost of the subsequent manufacturing operations.

In England, these acquirements have been attained in so high a degree, and the application of scientific knowledge has been so successful, that our iron-works now stand models at once of intelligence and ingenuity.

The progress of the manufacture of iron, from the earliest period to the present time, has been marked by the diligent researches of men of high capacity, whose united efforts have produced the comparatively perfect system we now employ.

The immense iron establishments of England stand pre-eminent, both as regards the mechanical skill which they display, and the practical management which is continually exerted. Machinery is made to produce economy in every department, and a result is thus obtained which appears to defy the competition of other countries. Intelligence and industry at home have enabled us to afford our products at so cheap a rate, that our iron has found a market in every civilised country. If the produce of the soil be looked upon as the greatest source of national wealth, doubtless the metallurgical products of the kingdom stand next in importance, and influence the rise and progress of this wealthy and powerful nation—due to the industry, perseverance, and acquired knowledge of a population whose energies turn to account our mineral riches, by exercising that untiring energy which marks so prominently the English character.

I will not enter upon a detailed account of the manufacture of iron, which has been so often explained, yet I shall be obliged to notice, as I proceed, a few of the processes, because I shall have to remark upon their present state of perfection.

It is in the immense laboratory of the blast furnace that the first operations are carried on for the production of pig-iron. Iron-ore, fuel, and fluxes are charged into the mouth of the furnace in such propertions as shall secure as pure a crude metal as possible.

The first important step is, to ascertain the average contents of the ore, which will be found to consist of certain earths combined with the metal, usually in a state of oxide alone, or oxide combined with carbonic acid. These earthy matters are not found naturally mixed together in such proportions as to secure their fusion—or perfect vitrification, freed from metallic matter. When, therefore, chemical analysis has given the quantity and quality of the earthy contents of the ore, other substances are added, in such proportions as will secure a perfect vitrification of the whole, in their passage through the blast furnace; these are called fluxes.

Iron ores are generally roasted, to open the mass, render it more porous, and at the same time to volatilise the sulphur, phosphorus, or arsenic with which they may be combined. These ores, in a state of peroxide, are charged into the furnace, in certain proportions, along with the fuel and the fluxes.

In examining the chemical changes which take place in a blast furnace, it is very extraordinary that the theory given by Professor Bunsen and Dr. Lyon Playfair has received so little consideration. The various gases which are produced in the different zones of the furnace have been collected and examined, and their action and re-action have been so verified by practical results, that it appears as though no doubt could exist upon the subject, and although chemical principles are clearly set forth, as regards the causes which effect the changes which take place in blast furnaces, yet they, nevertheless, become modified in furnaces differing in form, as well also from the nature of the ores, fuel, and fluxes used.

I will first examine the changes which take place in the passage of each charge of ore-fuel and flux, in its descent from the mouth of the furnace to the dam beneath. I will, then, lay before you the effects produced by the action of the blast upon the fuel, show at what points the various gases are produced, and how by their action upon the ore it becomes changed; thus explaining, as nearly as possible, the rationale of the reduction of the ores into metal, and the union of the earthy matter with the flux forming the slags.

The iron-ore is charged into the furnace as a calcined peroxide. Limestone is added as a flux, to unite with the earthy matter which the ore and the fuel may contain. During five or six feet of their descent, the moisture is expelled; they then become gradually heated to redness, and are prepared for reduction in the first zone of the furnace. Here the ore loses a portion of its oxide, and becomes reduced to a protoxide. These materials now enter the second zone, which ends at the boshes, or widest part of the furnace. At this point the ores are not only completely deoxidised, but become partially cemented. The limestone also has now parted with its carbonic acid, and the alkaline portion unites with other earthy matter, together forming a slag. The whole gradually, but slowly, descends through this part of the furnace, which is made wider, in order that the materials may take a longer time in passing through this space, thus leaving them for a longer period subjected to the action of the carbon. The metallic portion becomes gradually developed, and acted upon by the carbon of the fuel, and the highly-carbonising gases which it meets with in the lower region of the furnace. It then passes the direct action of the blast at the tuyere, and falling into the dam, separates itself, by its superior specific gravity, from the vitreous earthy matter which covers it, and protects it from the oxidising influence of the blast. Such are the changes which each charge undergoes in its passage through the furnace. I will now examine the cause of these changes.

The air which is blown into the furnace is composed, in round numbers, of 79 nitrogen and 21 oxygen. Before this air has risen three feet from the tuyere, it is converted into 65 nitrogen and 27 carbonic oxide; the nitrogen combines with a certain portion of carbon to form cyanogen, and the potassium which is obtained from the fuel, and sometimes from the ore and flux, unites with it, forming cyanide of potassium. The cyanogen is obtained by the union of the nitrogen of the air blown into the furnace, with a portion of the carbon obtained from the fuel, which, uniting with the potassium, is driven through the materials contained in the furnace, rapidly deoxidizing the ore in its passage, and gradually resolving itself into nitrogen, carbon, and carbonate of potash, the former, as gases escaping at the mouth of the furnace, and the latter, which is not volatile, uniting with the descending column of materials, and, reaching that region in which cyanogen is produced, is again transformed into cyanide of potassium. The strongest deoxidizing power is exerted as far as six to seven feet above the tuyere; it then diffuses itself as it rises through the mass of matter found in the boshes. So long as it retains that high degree of heat at which it is volatile, being carried up along with the ascending current of gases, it exerts this strong reducing power, and becomes gradually decomposed; thus, in the second zone, the carbonic oxide becomes the principal cementing medium, whilst in the first zone, this gas, combined with a light carburetted hydrogen which is evolved, commences the decomposition of the iron ore.

From this theory it will be seen, that the heat obtained in a blast furnace is generated in the lowest region, since we find that at three or four feet above the tuyere, all the oxygen injected is actually absorbed, giving rise to highly heated reducing gases, which, by the pressure of the blast, are in a manner forced through the furnace.

In all the theories which have been advanced respecting the cementation of the ores reduced in the blast furnace, this very important action of the cyanide of potassium has been neglected; yet from the first blowing in of the furnace it exerts an active decomposing influence, and as the furnace continues to work and the potassium to accumulate, the volume of cyanogen becomes necessarily increased, and although formed in the hottest region, its influence spreads over a large portion of the lower part of the furnace, and this action is the theory of what in practice is called getting the furnace into good working order. Such is the theory of those changes which take place in blast furnaces during the process of smelting.

As regards the construction of furnaces, generally speaking, they should have an internal form favourable to the gradual reduction and diminution of the volume of materials charged, which it is important should be so mixed that the earthy matter of the ore and the flux may readily unite; the descent of the materials in the furnace is regulated by the inclination and width of the boshes, and necessarily this inclination or width varies according to the nature of the ore which is to be smelted—those which are most easily reduced require the boshes to be the most inclined, whilst those which are difficult of reduction, and consequently require to be subjected to the action of the carbon of the fuel and the gases which are generated, for a longer period, are retained in this part of the furnace by greatly increasing its width, and giving the boshes a greater inclination.

In explaining this action of the blast-furnace, I have shown how the metal is reduced and carbonized, from which it will appear how difficult it is to obtain a pure metal, because, as it becomes developed in the lower regions of the furnace, it is necessarily mixed with substances forming a variety of metalloids; besides which, it is mechanically associated with the slag, which protects it in the dam from the oxidizing influence of the blast, through which it descends, carrying also with it a mixture of unreduced matter, which, from its gravity,

becomes more or less mixed with the metal when it is in a state of pig-iron.

Although the blast furnace is the most effective, and also the most economical, for reducing iron ore, yet we find that there is an actual loss, equal to 80 per cent. of the effective usefulness of the fuel. This fact is arrived at from the theory I have laid before you of the formation of gases in the furnace, taking the melting point of pig iron at 2192 Fahr. The fuel used together with the blast injected into the furnace, will give the quantity of carbonic oxide, light hydrogen, &c., which, when burned with heated air, would be sufficient to reduce or melt a given weight of iron from its ore, which in theory is estimated at between 16 and 17 per cent. of the value of the fuel consumed. These gases, so largely produced, are now collected in many works by means of pipes variously arranged, and inserted a few feet below the mouth of the furnace. They are used, mixed with a certain portion of atmospheric air, as a fuel for raising steam, heating the blast for the furnace, and on the Continent for the purposes of puddling; also for drying and carbonising the ore prior to its being charged into the furnace. If these gases are taken as they arise from the furnace, I see no objection to their being applied to useful purposes, but I do object to even the least forcible means being used to draw them from it. No current ought to be created in any apparatus which may be formed for conveying away these gases, since it would cause them to pass too rapidly through the furnace, and thus prevent them from producing their full effect upon the materials through which they are made to pass. This utilisation of the waste gases is highly interesting, and presents a wide field for application, besides which there is an evident economy to be obtained from their use, provided they are properly withdrawn from the furnace.

In the reduction of iron ores, it is very inportant to obtain the resulting metal in a state as free from deleterious matter as possible. To effect this, the ore is roasted to disengage all volatile matter and disintegrate the mass, such fluxes being used as shall, in the process of smelting, form vitreous compounds, by entering into combination with the earthy matter contained in the ore and fuel. Instead of giving any chemical formula, in order to show the relation one earth has to another, or the exact proportions of each which are required to form slags of sufficient fluidity, I will suppose that an iron ore be taken of a silicious nature and smelted alone, the result would, of course, be a silicate of the oxide of iron, like finery cinder. We will look upon this combination as that of an acid with its base, the acid being combined with the oxide of the metal. In order to liberate the metal, this combination must be decomposed by some other alkaline bases which have a greater affinity for the acid, and unite with it, forming new compounds, at the same time liberating the metallic oxide; so it is in the blast furnace. Iron ores become soft during the process of deoxidation, they eventually melt, and in that state require to be in immediate contact with one or more alkaline bases, so that they may prevent the formation of the silicate which would otherwise take place. Limestone is the matter used for this purpose; it is well adapted to the object, but, in my opinion, the large amount of carbonic acid which it contains is prejudicial, because, in its descent, volumes of this gas are given out, which absorb a large portion of the heat from the materials in the furnace, thus cooling the region where such absorption takes place, and often producing very serious derangements in the working of the furnace. Since a certain amount of alkali is required to saturate the silicious matter, that object would be best attained by introducing such alkali in as condensed a form as possible. I am therefore a strong advocate for the use of caustic lime instead of limestone, because the carbonic acid which forms 40 per cent. of the bulk is not wanted, and it is a waste of fuel to heat so large a mass of what may be called sterile material. Salt has been proposed as a flux, and in small doses will be found very beneficial.

Sir Francis Knowles, struck with the functions of the cyanide of potassium, proposes to introduce potash, felspar, or soda into the furnace charges; he adds lime, equal to two-thirds of the weight of the silica contained in the felspar; the bases then become lime, alumina, and the alkali, which being in excess, is released to form the cyanide required; he states that his trials have given him a cinder entirely free from iron; he has also patented the use of kaolin or china clay as a flux; this substance consists of 47 per cent. alumina, and 52 per cent. silica, so that even when the silica is neutralised there yet remains 30 per cent. of alumina to act upon that contained in the ore; kaolin is thus much superior to shale, which only leaves about 10 per cent. of free alumina after the silica is neutralised. I believe some experiments are now going on to smelt forge cinders with kaolin, and, if they are successful, this substance may be beneficially applied to all silicious ores. He further proposes to deoxidize the rich ores prior to their being charged into the blast furnace, by charging them into large retorts heated cherry red, and passing through them a current of carburetted hydrogen gas, which he obtains from the coke ovens; he finds that peroxides can be thus converted into protoxides in two hours, and that in three or four hours they assume the appearance of metallic iron; ore so prepared, he states, will at once go down as grey iron on arriving at the boshes; as an economical means of carbonising the ore, he takes the waste gases of the furnace and passes them in a highly heated state through the fuel to be coked; the gases evolved are stored in a gasometer for use.

Many ingredients have been from time to time proposed for improving the quality of crude iron, but acting as they do upon so large a mass of matter, but little benefit has yet been derived.

The pig iron which is produced from blast furnaces varies in quality, that is, the iron is more or less mixed up with matter which is not metallic, whilst the iron itself contains more or less carbon. In charcoal furnaces, in which the rich ores are generally smelted, and in which the fuel is not so strong as coke to withstand the strong blast, or the superincumbent pressure of the ore, great care is required in adjusting the burthen of the furnace; if a heavy burthen of ore be used, with a view of obtaining cheap pig iron, using only a small portion of fuel, it is very evident that the ore will pass too rapidly through each region of the furnace; it thus retains and carries with it a large portion of deleterious matter, and but a small dose of carbon; such metal is thus unfit for casting purposes, and when manufactured into malleable iron produces much waste, and retains all the bad properties which the metal contracted in the blast furnace.

The trade divides the qualities of pig-iron into numbers, 1 to 4; the more carbon it contains the more fluid it becomes on melting. No. 1, is that most highly carbonized; 2, 3, and 4, contain each a less degree of carbon, whilst the common white iron contains only a small portion, having been made to pass too rapidly through the furnace, and consequently become mixed with much deleterious matter. Nos. 1 to 3 are principally used for casting purposes, whilst No. 4, and all metal less carbonized, is used for the manufacture of rails, and common malleable iron.

There has been much controversy as respects the relative strength of hot and cold-blast iron; I do not propose to give at length the reasons alleged by the supporters of the superiority of either kind; but I wish to observe that, inasmuch as iron becomes stronger in proportion as the metallic molecules of which it is composed are brought closer together, it appears to me most probable that pig-iron produced by cold blast, and under such circumstances as to ensure the production of the purest iron, would be most likely to produce the strongest material for casting purposes. With this theory, as re-

gards the strength of iron, I must at present leave this most important matter, although much more might be said upon a question which has been too often the cause of serious accidents, but which involves so much minute inquiry that my time will not allow me to say more than to express the opinion, that pig-iron may be materially improved for casting purposes, and made much stronger for mechanical and engineering objects, as well as the no less important purpose of ordnance. I base this opinion upon the theory I have just advanced, that iron increases in strength in proportion as the molecules of the metal are brought closer in contact, without producing crystallization; and this can only be effected by discharging a large portion of that deleterious matter with which the metal becomes associated during its production in the blast furnace, and, as iron for casting purposes can be thus improved, its application will be materially increased.

In the foregoing, I have endeavoured to explain the theory of the production of pig-iron in the blast-furnace, and, at the same time, have endeavoured, as far as possible, to make this theory agree with every-day practice, although I have condensed the subject into the smallest space, yet I feel how very little my time has allowed me to lay before you, upon the manufacture of a metal which finds employment for so large a portion of our population. The plans which have been proposed for the utilisation of the waste gases are a subject of great interest, since this is the only step which has been made to recover the effect of that fuel which is now lost. The relative effects of coal as a fuel, instead of coke or anthracite, I have not been able to touch, whilst the use of fluxes I have simply reduced to a general theory. I trust, however, that these points will be taken up by others, since they are sufficiently important to form separate papers for discussion before the Society, the principal aim of which is, to advance the improvement of our staple manufactures; and this can only be done by eliciting from practical men descriptions of processes generally in use, and particularly encouraging improvements.

Pig-iron I assume as the crude raw material from which its staple manufactures are produced. A very large proportion of the pig-iron made in this country is converted into malleable iron. Common iron and rails are made from the cheapest descriptions of pig-iron, but for the better kinds a superior pig is used, and for the best iron refined metal alone, or mixed with charcoal pig-iron. In those works in which common iron is made, the blast furnace manager's talent is exercised in keeping his furnace exactly in such a state as is favourable to the production of a maximum quantity of iron, with the least possible consumption of coal, or waste of the materials used. Under such circumstances, it cannot be expected that a pure iron will be produced, the effort made to obtain quantity necessarily affecting the quality.

In the manufacture of merchant bars, and iron of similar quality, pig-iron is charged directly into the puddling furnace, and is subjected to a process called boiling. Malleable iron thus produced is much inferior in quality to that obtained from refined metal, because all the deleterious matter which the pig-iron contains, being mixed up with the metal as it is being puddled, necessarily becomes more or less incorporated with it, and materially affects the quality of the puddled bar. Being alloyed with the silicated slags produced, its power of tenacity and strength becomes weakened. The waste in the puddling furnace is very large, and this loss is again seriously felt in all its subsequent manufacture, being caused by the absorption of a large portion of metallic matter by the slags produced from the impure iron. I have been told by the chief managers of two of the large Welsh works, that they had, on an average throughout the year, consumed 28 cwt. of pig-iron in the production of every ton of railway bars. In the manufacture of malleable iron, we find the cost consists of coal, labour, and the crude metal employed. If the puddling furnaces are well-constructed, no material economy can be made in the present consumption of coal, and in the ordinary state of trade no reduction can be expected in the cost of labour. If, therefore, economy is to be made in the manufacture of malleable iron, it must be by a reduction in the waste of metal which is now experienced in puddling and other furnaces used in iron-works. In Wales, this large waste is experienced by the use of a low carbonised white iron, containing much foreign matter; but in Scotland, a similar waste results from the circumstance that the pig iron is too highly carbonised, from which cause it has to remain much longer in the puddling furnace before it can be brought into nature. This prolonged application of the heat produces so large a waste, and entails such heavy work upon the puddler, that in Scotch malleable iron works it is the custom to refine part of their pig iron in order to get rid of a portion of the carbon, and thus accelerate the puddling process. The intermediate plan of refining pig iron has been introduced between the blast and the puddling furnace, in order to clear away, as far as possible, that foreign matter which it has taken up, as well as to dissipate a portion of the carbon, but since it is absolutely necessary to keep the cost of the production of bars or rails within a certain limit, it is imperative upon the manufacturer that such operation shall entail no ultimate expense, and this can only be effected by reducing the waste of iron so low in the puddling and reheating furnaces, that the weight saved shall compensate for the expense of refining. The present plan for producing refined metal is very costly, averaging 15s. when pig iron cost 70s. per ton. This becomes a serious charge upon the metal in its earliest stages of manufacture, and although malleable iron made from refined metal is much superior to that made from pig iron, yet owing to the great expense of refining by the usual process of a strong blast, together with the waste experienced, and cost of fuel and labour, the prime cost of the finished bar becomes so seriously affected as to prevent its general use. I have devoted considerable time and expense to this desirable object, and I have succeeded in producing a highly decarbonised refined metal, at a cost not exceeding 5s. to 6s. per ton, including waste and every other expense. This metal produces a puddled bar with a waste of only 1½ cwt. per ton upon very common iron, and as low as 1 cwt. per ton, if the refined metal be made from strong forge pig iron. Upon a calculation, based on the manufacture of 100 tons of Welsh iron, re-melted from the pig, ⅓ being white iron, and ⅔ mottled pig, the waste in refining was 90 lbs. per ton, and upon a quantity of 60 tons, drawn directly from the blast furnace in a fluid state into my refining furnace, a loss of only 60lbs. per ton was experienced.

Two furnaces in one of the large Welsh iron works puddled this refined metal for twelve consecutive days, and the average waste during that period was only 84 lbs. per ton; the pig from which this iron was made had no cinder in its composition. I present for your examination several samples of this refined metal, which is produced with the greatest facility; also of the slags which result from it. The objects of this process are to reduce the loss of metal, and to use coal instead of coke as a fuel; to effect a uniform decarbonisation of the pig iron without the use of blast, to use a chemical reagent capable of giving out oxygen during its decomposition, which, taking up and uniting with the carbon evolved from the metal, produces carbonic oxide gas, and this, acting upon the earthy compounds contained in the pig iron, precipitates the metal contained in them, by which means I obtain very clean, pure, crystalline metal, capable of being manufactured into superior malleable iron. There are samples of malleable iron manufactured from this refined metal, also a sample of the pig iron used to produce the refined metal, several tons of which were puddled in Yorkshire and rolled into rivet iron, which was used for rivets in the *Leviathan* steamship, and reported

of excellent quality. This iron when finished experienced a waste of only $3\frac{1}{2}$ cwt. per ton. By this process I refined a mixture of 15 cwt. of number 3 hot-blast pig, and 6 cwt. of cold-blast charcoal iron; the metal was puddled and rolled directly into a bar, then converted and melted into cast steel; the files and saws which are exhibited were manufactured from this steel, and show the purity of the metal from which they have been made. The gun-barrels are made from the rough puddled bar above mentioned, melted without conversion. These two samples were manufactured under the inspection of one of the government officers for small arms, at Birmingham, and have been tested at the proof house. There are several other samples of this quality of iron; it is somewhat expensive, but it is the purest iron which can be produced, having been melted and thus divested of all its foreign matter. It is a proof also of the great additional strength which iron acquires when the metallic particles are made to approach close to each other. My refined metal has been successfully tested for tin plates There are samples of this iron made in the puddling furnace, and refined with charcoal, in both instances the waste was reduced one-half when compared with pig iron. The tin plates manufactured from it are reported of good quality. The metal has also been found equal in quality to charcoal pig iron when used for the manufacture of very common cutlery, called run steel. The articles before you will show that it admits of being hardened and tempered.

In making castings, whilst additional strength can be given to iron by cleansing it from earthy matter, yet care must be taken that in reducing the amount of carbon, the metal does not crystallize; a fine grain is favourable to great strength, which can only be attained by the purification of the pig-iron itself, when very strong castings are required. I recommend that the pig-iron which is used should undergo a remelting, adding such reagents as will unite with much of the earthy matter contained in the pig, but which will not extract the carbon; such iron will make stronger castings, because the metallic particles are brought in closer contact; I find also from experience that an addition of my refined metal to such purified iron will give still greater strength.

Highly refined metal is not fit for castings; it is as bad as the use of hard cast steel, because the disaggregation of the mass, arising from crystallization, weakens the whole body.

Much has been advanced in favour of the manufacture of ordnance from cast-steel. I do not think that good and serviceable pieces of artillery can be manufactured from such metal. There is no great practical difficulty in casting a mass of steel 2 or even 3 tons weight, but the irregular crystallization of so large a body of steel, melted in parcels of 50 lbs. in a crucible, is unfavourable to that uniform molecular structure which such castings should possess, since upon their excellence often depends the issue of a siege or action.

Although wrought-iron ordnance cannot be depended upon, they are better than cast steel, but their perfection is much impaired by the necessity of piling masses of iron together. I admit that a weld can be perfectly made, but two surfaces when oxidized can never become one amalgamated body, without the oxygen be reduced at the moment when the union is effected. Wrought-iron guns have given excellent results when fired at slow intervals, but if a continuous quick firing were kept up, I doubt their being able to withstand the shocks; they would, I think, after each round, become gradually weaker throughout the welded surfaces.

It appears of very great importance that some means should be devised for producing a material combining the greatest strength with durability, not only for the construction of rails, but also for tubular bridges, steamships, and a great variety of similar purposes, not only to prevent loss of life, but also to secure an eventual economy. No plan appears so effective as that obtained by the union of iron and steel; such a compound metal will, I believe, furnish a better and a cheaper means of effecting this great object than by the use of iron alone. Large masses may easily be obtained through the medium of the welding property of cast steel in a fluid state. A bloom of iron is heated white hot, placed in a cast-iron mould, and fluid steel is poured against it; the effect is, that the carbon of the steel reduces the oxide on the surface of the iron, and a union like that of silver plated on copper is obtained, rather than a common weld. Two pieces of iron may thus be united, by pouring cast steel between them when heated, forming a mass of great strength, and useful in machinery, where considerable strain is exerted, on account of the stiffness and strength of the steel being united with the toughness of the iron.

Now, more than ever, we require the means of rapid transit in our Indian possessions, to enable us to retain our supremacy in that distant portion of our empire; present experience shows us that we must take immediate measures to enable us to concentrate at any one point those means of resistance which must, in future, be kept at all times ready to protect both life and commerce. To do this, main lines of railroad must intersect the length and breadth of India, whilst light draught steamers must open out an inland navigation which does not now exist. A compound metal of iron and steel, from its combined strength and lightness will, I believe, furnish a better and a cheaper means of effecting this great object than any which can be obtained by the use of iron alone. I beg to submit to your notice a new form of rail; it is made from a thick plate of iron and steel united as described; the plate, when hot, is bent up into the form of a rail, the steel coating being outside, before the bar is cold; it is hardened by being plunged into cold water and tempered in the usual way; by these means are obtained, not only great combined strength by the union of the two metals, but a further addition of it, equal to 33 per cent., is made by hardening and tempering the steel, which not only prevents the running surface from rapid wear, but, what is of the greatest importance, such rails can never laminate—the elasticity acquired by the hardened and tempered steel portion of the rails will prevent them from setting when bent by sudden and undue pressure; they can be made of any thickness, according to the nature of the traffic; the main line might be laid with rails like the thicker model, which is equal in strength to the double-headed rail now used, which weighs 84 lbs. per yard; but many districts might only require rails like the lighter model. The advantages this rail presents are great strength, great resistance under undue pressure, a hard non-laminating surface, which will wear very much longer than those now used; but the most prominent value is their extreme lightness, combined as it is with great strength, which becomes of such high importance in the first cost of a railway. The rail of the heavy model is 36 lbs., and that of the light one 26 lbs. per yard; if you admit for a moment that my statement is true as respects their strength and other qualities, allow me to suggest to you the valuable advantages which such a rail presents in point of economy, and the large saving made, especially to colonial railway companies, not only in freight from England, but the more serious expense of inland transport. I will not go into the various forms which engineers might think it best to give to rails made from such material, but there does seem to me one great advantage in the mode which I have adopted to attach the rail to the chair. The model of the saddle rail is like that used on the Great Western, but it is stronger on account of the material used. In countries where wood is cheap, a modification of this rail might be laid down very economically.

I propose the use of iron and steel united in a bloom, and subsequently rolled to a sheet, hardened and tempered in order to obtain the maximum amount of rigidity

combined with strength, as a material for the formation of steam ships; and it will be found equally useful in the erection of tubular bridges, and many other engineering purposes.

In these days of steam navigation, I would request of those who are engaged in building iron steam-ships to investigate the usefulness of such material, and to inquire into its cost. No doubt it may be expected to be expensive. I am enabled to state, however, that it can be produced at a sufficiently low price to ensure its use, and whatever increase there may be in cost, will be more than compensated for by the difference of weight required of this material contrasted with that of iron.

The value of puddled steel has recently been brought under your notice. I can add little to the opinion I then expressed; the process will certainly produce steel, but from the nature of the operation itself, it must be evident that the quality is continually subject to great irregularity. All agree that the greatest care is necessary to produce it. More uniformity may be obtained by breaking up the rough bar, selecting them when cold, and welding them together; still the mass is simply steel combined with fine fibres of iron intimately intermixed. It will become a useful metal for a great variety of purposes where a cutting edge is not required, but looking at puddled steel as a raw material to be manufactured by the peculiar process which has been described in the patent, I still think that if refined metal were puddled, shingled, and rolled to a bar, and then converted into steel by the usual process, a cheaper and more uniform material would be obtained. I take this opportunity of repeating, that the conversion of bar-iron into steel ought not to cost more than 18s. per ton. My calculation is drawn from careful accounts kept of the working of ten converting furnaces for five years, during which period one-half of the iron was converted for hard melting purposes. From this, I positively affirm that the conversion of puddled bar-iron, in order to give it as much steel character as that possessed by puddled steel, ought not to cost so much as 18s. per ton, including every other expense.

Some engineers have objected to rails, even if made from cast steel. They say no dependence can be placed upon such a material, because it has no toughness. Its crystalline fracture is objected to, on account of brittleness, especially in very cold climates. The form of rail which I have submitted to you might, of course, be made wholly from steel, but I object to this material, because rails are subject to sudden violent concussions, which might snap a steel bar, and thus place the line in danger.

For some time past our scientific journals have been filled with various projects for the production of steel, especially cast-steel, at very cheap rates. After all the apparently feasible projects which have been suggested, nothing of any importance has yet been done to attain this object; the steel which has been produced by these various processes does not appear to possess that quality which has been so positively stated; hitherto cast-steel has been made varying from £65 to £30 per ton, each quality being practically useable for the manufacture of steel articles. The manufacture of such steel has hitherto been the peculiar province of the Sheffield makers, but let it not be supposed that they can make no other material than that used by the cutler, the tool maker, and the engineer; let them see that a want is created for a steel suitable for the manufacture of shafts, steam ships, tubular bridges, and other like purposes, where strength and rigidity are the principal acquirements, it will be found that they are the best able to suggest modes for producing such an article, of uniform quatity and at a cheap rate. Science can greatly assist art in producing the kind of steel required for general engineering purposes; and highly as I esteem this combination, I would earnestly advise the practical metallurgist not to come to hasty conclusions from laboratorial experiments. With the metal steel is associated the idea of great expense; good steel will always sell at a price consistent with its intrinsic quality, and, if care, skill, and expensive raw material be required to produce such a steel, an adequate price will always be found for it; but, if, on the other hand, a metal be required combining within itself a much superior strength and rigidity than iron possesses, I feel no hesitation in saying that it can be produced by the large steel manufacturers of Sheffield at a cheaper price and of a better quality, than by any of the peculiar processes patented within the last few years; although I do not think that a process is yet discovered which secures the minimum cost price of the production of such material, yet this enquiry is going forward, and will, doubtless, be speedily arrived at. Whether such discovery emanate from existing steel-makers, or from others, not engaged in this trade, its production, at a cheap rate, will confer the greatest benefit, not only upon our railroad requirements, but also upon our steam navigation; we may then hope to have better and more efficient rails, stronger bridges, and safer steam-ships.

As regards the direct conversion of pig-iron into malleable iron or steel, without the pudling furnace or charcoal refinery, I have already expressed a strong opinion, when that process was first proposed, at the meeting of the British Association, at Cheltenham.* I still see no cause to change the opinion I then expressed, that neither practically useful malleable iron, nor cast-steel, could be produced direct from pig-iron. It is by no means a common practice to use refined metal (which is decarbonized pig-iron), as a mixture with any common material, such as scrap iron, clippings from old boiler plates, and the like, to produce a common cast-steel, which is sold at from £16 to £18 per ton, for making mill saws, and several very common cast-steel articles, but the only quality, as a steel, which it possesses is, that it will harden and temper.

When it was found that the decarbonized pig-iron, resulting from the process of blowing a strong blast of air into a body of fluid iron, would not roll or draw under the hammer, Mr. Robert Mushet patented several processes, with a view of rendering this product malleable; manganese, mixed with carbonaceous matter, is suggested by him as a means of obtaining malleability; he asserts that he can operate upon one or twenty tons of fluid metal, by blowing a strong blast into it, and when, by this means, it is decarbonized by adding from 2 to 20 per cent. of manganese and carbon, he professes to change a brittle metal into one capable of being rolled, or hammered, hardened and tempered. There is a sample of Mr. Mushet's steel, but I have no information as to whether it has been produced in the manner described, or whether he has had recourse to the crucible to remelt this metal.

A patent was taken out a short time ago for mixing decarbonized metal with malleable iron; this process was first carried out at some cast-steel works belonging to Prince Schwartzenburg, at Muraw, in Styria; the late Mr. Heath also used it at his works at Chelsea; in both these instances, although the finest charcoal metal was used, yet a good quality of steel was not regularly produced; as a manufacture, the process was imperfect.

Patents have also been taken for the production of cast-steel from iron ore; many experiments have also been tried, both in England and France, to produce a cheap steel from such an inexpensive material; by Monsieur Chenot's process, the iron is separated from other deleterious matter by an electro-magnetic machine; to the material so obtained, a thick lime water is added, to prevent the particles sticking together, and forming a compact mass during the process of deoxidation, which is performed in small perforated iron vessels, by passing through it a current of carbonic oxide gas; this deoxidized spongy mass is then steeped in any kind of fatty matter; from this source, he says he obtains the constituents of steel; he proposes also to condense the spongy matter by pressure, and submit it to the usual process of cementation; it is then to be melted into cast-steel.

There has been much said respecting a process for

producing cast-steel from a mixture of spathose iron ore and granulated cast-iron; but from the reasons I shall shortly lay before you, I think no successful or practical result will be obtained.

Sir Francis Knowles has also patented a process for making cast-steel from iron ore; he says, that if the complete success of the process be doubted, it is impossible to deny that it rests upon a theory both rational and consistent with chemistry; he looks upon the manufacture of cast-steel from British materials as of national importance, by rendering us independent of Sweden, or any other country. There is before you a complete set of samples of this steel, also a variety of manufactured articles, from which you can judge of the progress which he has made. His theory is as follows:—If the oxides of iron be placed in a closed retort or crucible in contact with charcoal, and submitted to adequate heat, the metallic part, as soon as it is deoxidized by the charcoal, begins to absorb carbon, and is, in fact, converted; if then no more charcoal be admitted than is exactly sufficient to deoxidize the ore, and to convert the metal to the required temper, it is plain that the absorption of carbon will then cease; and if at this stage the heat be gradually raised to the steel melting point, the production of steel must be the inevitable consequence. In sending the examples I am enabled to exhibit, he observes, in order to adjust the charcoal, we must know how much metal there is in the ore, and what is its state of oxidation; preliminary chemical analysis will settle this point. The next step is so to adjust the fluxes, that protosilicate of iron may not be produced, and for this purpose chemistry must determine what earths are contained in the ore and the fluxes—a calculation must then be made, so that the aggregate may be a combination of the silicates of alumina, lime, magnesia, and the potash of the charcoal used. Magnesian dolomite calcined is preferable; in its absence the purest lime is to be used; the other flux he uses is kaolin, which is so rich in alumina; there is an additional value in this, as it prevents the corrosion of the pots, when in proper quantity. The best ratio of the earths is three silica, two alumina, two lime; samples of the cinder are here for inspection, being pure and free from protoxide of iron. The most striking feature of this "ore steel" is it very great density; this he ascribes to the total absence of the protosilicate of iron in the cinder. Amongst the articles is a chisel, taken from an ingot; merely ground, and hardened, and tempered, it has cut to pieces a bar of file steel. This striking property has led to its employment for the cogs of wheels and other important purposes. He also uses the Greenland cryolite, and cyanides of sodium and potassium, as fluxes. He has also contrived a furnace or cupola for making steel by this process; it resembles an ordinary blast furnace, except that the materials, mixed in proper proportions, are carefully secluded from the fuel, and descend through a long pipe of refractory fireclay, and through the various degrees of heat required, to the hearth of the crucible. Whether steel can be directly cast into ingots from such a furnace is at present doubful; but there cannot be a doubt that a steel metal will be obtained. Sir Francis Knowles does not disuse altogether the present method of conversion; on the contrary, his opinion is, that, for certain purposes, it is the best and most economical, as for some of the milder tempers—but whenever the operation of melting is required at an intermediate stage, there he would substitute the direct method, and, above all, for cutting tools, of every description, and the highest class of cutlery. Such is Sir Francis's own statement.

The foregoing are the prominent processes which have recently attracted public notice, having for their object a reduction of the prime cost of making cast steel.

As regards all steel produced by the decarbonisation of crude iron—if we examine the peculiar state of this metal it will be found, that the mass is composed of atoms irregularly decarbonised and impure; besides which, we find in such masses of metal a variety of combinations, all of which are opposed to malleability, because the aggregated molecules of such mass are not homogeneous, but are mixtures of metal existing under different chemical circumstances, which give to each molecule a different crystalline structure, so that, when heated, they expand unequally. All these opposite and conflicting states, in which decarbonised pig-iron is found, prevent the mass from drawing or rolling. If lumps of iron are drawn from the puddling furnace a little before the mass is balled up, a bright and crystalline metal is obtained, similar to this decarbonised crude iron; it is partially malleable, but it has no fibre to recommend it as an iron, nor has it carbon to entitle it to be called steel. Mr. Mushet has evidently the idea that the addition of his compound will produce one uniform crystallisation, favourable to malleability, and he appears to expect that an alloy will be found of metallic manganese with the iron, but analysis has shown that no such alloy does take place. Manganese, added to steel, in the crucible acts simply as a detergent; it cedes its oxygen to the silex, which the silicates of the metal may contain, and oxydises it; a union then takes place, producing a silicated oxide of manganese, in the form of a glassy slag; the metal becomes thus purified, because all foreign matter is separated, forming new compounds, which cannot again unite with it. In any attempt to produce cast steel from decarbonised pig iron, it must be broken up when cold, and such reactives added to it when charged into the crucible as shall take up the deleterious matter and liberate the metal, which must be kept in a fluid state for a long time, until every particle is reduced to the same chemical condition, and thus rendered more favourable for malleability; but this is so nice an operation, and so dependent upon uncontrollable circumstances, that it is not reduceable to practice.

As regards all those processes which have for their object the manufacture of cast-steel from iron ore, I may in part advance the above theory against their success, but there is another cause which operates very unfavourably. Iron ore may be deoxidised and used as M. Chenot proposes, or it may be charged into a crucible along with carbonaceous matter and fluxes, and slowly heated until deoxidation takes place; when the cementation is complete, a mass is obtained in the crucible consisting of earthy matter intimately mixed with steelified metallic particles, all which have to be melted down into one mass. I think no one can reasonably assume that all these metallic particles, intimately mixed as they are with the earthy matter, can be in the same chemical condition, nevertheless the metal must all be melted down in this imperfect state; the metallic part more or less carbonised and mixed with foreign matter falls to the bottom of the crucible, simply from its superior specific gravity; in order to give every chance for the matter to clear itself and become uniform, it might be kept in a melted state for some time, but for all this the operation carries with it no certainty either as regards quality or temper. I manufactured a ton of ingots from a very pure black oxide of iron; using every possible care, not more than 7 cwt. could be drawn into bars at all, and the fracture was very irregular, which may be observed in the sample; a part of this steel would not draw, but broke in pieces; the rest drew more or less imperfectly, and, on a careful examination, I found it very evident that the chemical condition of the metallic particles was so dissimilar that malleability could not be depended upon. In order or as far as possible to prove this assumed case of irregular malleability, I took soft steel in one crucible and very hard steel in another, and mixed with each a quantity of earthy matter, as nearly as possible to imitate the condition of the iron ore when melted; when they were completely melted they were intimately mixed together, and an ingot was cast; but although very carefuly heated it would not draw; this was not because any earthy matter was mixed up with the metal, but because its carbonization was variable throughout the mass, which gave rise to such a confused diversity of crystallization, and caused so great a difference in the

degree of malleability of the atomic structure of the mass, that the action of the hammer at once broke up the ingot; the want of tenacity or disaggregation of the mass is often seen in large ingots, although made from good material; this is caused either from the irregular temper of the steel used, or from its having undergone a complete change in the crucible by over heating it, and thus causing a mixed crystallization; or it may equally arise from being under melted, which it is evident would produce the same effect. As I have stated, ingots of cast-steel can be produced directly from iron ore, but the best portions harden very irregularly, whilst the mass is usually so imperfect as to be unmerchantable. I admit that a cheap metal may be produced, but, as I have shown that there is no certain result to be obtained in its manufacture, so also there is no economy. I will not assume that those who have been so sanguine in the production of cheap steel can have expected to produce a superior quality suitable for the best purposes; I cannot suppose such to have been their object, but rather to obtain a cheap material in a fluid state, capable of being cast into large masses for engineering purposes, or objects which are now manufactured from malleable iron—such as shafts, beams, girders, plates for ships' bridges, &c., &c. In a commercial point of view, England is the only exporting country to any extent. Sweden sends to England about 30,000 tons annually for steel purposes; she also exports largely to India and North America. Russia also exports to England about 10,000 tons of steel iron; a portion is sent to the United States in bars and in sheets, which are manufactured by a peculiar process, having a very fine black polished surface; the rest of the produce is either consumed within the empire, or finds a market in Asia Minor and the East. Prussia has, within a few years, largely increased her production, and still continues to expand; she has not, however, exported her produce, but, on the contrary, has required considerable importations of pig iron; for in 1857 she received from England 67,297 tons, against 39,296 tons sent in 1856, being an increase of 28,001 tons, and equal to 67½ per cent.

France does not appear to have made any advance since the alteration in the tariff admitted English iron at a reduced duty, which all her iron masters are now seeking to repeal; it will, of course, become a national consideration, whether they are to hold the monoply they seek, or whether the manufacturing population are to maintain their position—since the cost of iron in most countries is now becoming, as it were, the standard of its riches. In 1856 she imported from England 84,923 tons of pig iron; in 1857, 89,401 tons, making an increase of only 4,478 tons; whilst of rails and bars, in 1856, she imported from us 71,344 tons, and in 1857 only 30,136 tons, showing a large decrease of 41,208 tons. In the United States, although many of their iron works are not in operation, and others, like our own, at present doing very little, yet, in the early part of last year they were producing one million of tons of pig iron per annum, and from their vast mineral resources they will again, after a time, go on increasing; they do not export—on the contrary, in 1856 imported 58,500 tons of pig iron; in 1856, 46,752 tons, showing a decrease of 11,748 tons; again, in rails, bars, &c., in 1856, they imported 231,555 tons; and, in 1857, 221,430 tons, showing again a decrease of 10,125 tons. In sheets, plates, &c., in 1856, 45,714 tons were exported, and in 1837, 46,497 tons; giving a small increase of 783 tons. On the whole, therefore, it appears that their own resources have reduced the import in 1857 to the extent of 20,000 tons, this reduction may, however, have partly arisen from the existing state of their public works and general trade.

The exports to all countries, for the first three months of the present year, show a decrease upon 1857 of 149,021 tons. The decrease has been chiefly to the United States, being 118,236 tons out of the whole. The total decrease of our exports this year is 31 per cent., equal in money to £1,447,479.

If, then, we take a review of the iron produced in different countries, we find that the charcoal iron produced all over Europe, is either consumed in the country where it is made, or sold to neighbouring states. Prussia, France, and the United States, alone make iron from coal or coke, but they do not export. England stands alone; her immense product supplies the want of every kingdom and nation. How is it that we have secured a position over all other countries, which enables us not only to supply iron cheaper than they, but also to pay the expense of transit, import duties, and a variety of other charges, and still compete with their own producers in their own markets?

We are fortunate in possessing large deposits of ironstone and coal, but we are still more fortunate in possessing the highest intelligence, an industrious population, and unlimited pecuniary means for carrying out the production of iron upon the most extended scale. In mining, in the management of the blast furnace, and in all the various processes for the production of malleable iron, knowledge has been added to knowledge, experiences have been so multiplied, and the system of iron making is now so perfect in itself, that by the statistics of the British iron trade, we find England exporting iron and articles made therefrom to the enormous amount of £22,994,671, finding employment at home for a large industrious population, and supplying freight for our own merchant navy. This state of things will not only continue to exist, but our exports must continue to increase, so long as, by our industry, capital, and knowledge, we continue to produce iron at so cheap a rate. Improvement in quality is highly important, if it can be combined with the economy now practised, and must give an additional security to our commerce. Iron masters may say, our plate-iron and our rails are good enough; I fear such an assertion could not be upheld; our rails, generally speaking, are not so good as they can be made, and the almost daily reports which we hear of the defects of our iron built steam ships, are proofs that this kind of iron might be improved, and this can only be done by giving the maker a better price. I am perfectly aware that to maintain our supremacy over other countries the most rigid economy is necessary, but if our large iron makers hope for prosperity, and if those who embark such large sums of money in iron establishments look for a manufacturer's profit, they must be careful how their money is expended in mines, machinery, and general works; they must avoid the incubus of a heavy dead capital. Certain works may be able to produce 1000 tons or more weekly, and I will admit (for my argument's sake) that the strictest economy is throughout observed, from the raising of the ore and coal, to the despatch of the finished iron; but upon all the various costs and charges which belong to the production of the iron, the interest upon a large amount of dead capital has to be brought into calculation, at such a rate as shall not only cover common interest, but also the wear and tear, and the yearly diminution in value of works in operation. I will not venture an opinion how heavily they bear upon some large works, nor can I say how much capital has been irrecoverably lost, for want, at the outset, of a clear knowledge of all the requirements of iron works, but I know that such an item does fall very heavily upon each ton of iron produced. Were it in my power to look back into the private history of many large works from their early commencement, and gradually to trace the expenditure of their capital, I should find large sums devoted to projects of which no vestige now remained; whilst the erection of the requisite machinery had cost more than double its original estimate. If such works were to be sold at a price ascertained by a fair valuation, perhaps, that which by degrees, one way or another, had cost £500,000 would be found not to be worth half that sum. If iron works are intended to pay, their projectors must bear in mind that every £1,000 sunk in the works, &c., will eventually inflict a charge per ton upon their produce; and the smaller such produce is, the heavier

EXPORTS OF IRON TO VARIOUS COUNTRIES IN THE YEARS 1856 AND 1857.

PIG IRON.

To	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Australia	...	..	...	...	...	...	...	...
Brazil	...	...	...	...	...	...	...	...
British North America	12,428	15,922	45,886	61,754	3,494	15,868	...	...
East Indies	...	...	...	...	...	...	...	...
Egypt	...	...	...	...	...	...	...	...
France	84,923	89,401	326,552	331,957	4,478	5,405	...	...
Hanse Towns	...	...	...	...	...	...	...	...
Holland	54,258	83,226	212,021	328,566	28,968	116,545	...	...
Prussia	39,296	67,297	151,509	254,733	28,001	103,224	...	...
Sardinia	...	...	...	...	...	...	...	...
United States	58,500	46,752	228,620	180,953	...	...	11,748	47,667
Unenumerated Countries	107,921	120,617	420,530	453,504	12,696	32,974	...	...
Total in 12 months	357,326	423,215	1,385,118	1,611,467	77,637	274,016	11,748	47,667
Deduct [Increase or] Decrease					11,748			
Total Increase [or Decrease]					65,889	226,349		
Per centage of Increase [or Decrease]					18½	16¼		

CASTINGS.

To	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Australia	15,801	7,787	170,572	108,539	...	...	8,014	62,033
Brazil	3,992	4,726	51,612	61,795	734	10,183	...	...
British North America	5,293	5,935	33,667	44,168	642	5,501	...	...
East Indies	16,162	18,421	114,211	151,096	2,259	36,885	..	...
Egypt	55	833	917	12,676	778	11,759	...	...
France	...	...	...	...	...	...	...	...
Hanse Towns	...	...	...	...	...	...	...	...
Holland	...	...	...	...	...	...	...	...
Prussia	...	...	...	...	...	...	...	...
Sardinia	1,870	279	16,354	3,829	...	...	1,591	12,525
United States	835	2,587	22,101	30,855	1,752	8,754	...	...
Unenumerated Countries	28,386	32,212	297,743	341,661	3,826	43,918	...	...
Total in 12 months	72,394	72,780	712,177	754,619	9,991	117,000	9,605	74,558
Deduct [Increase or] Decrease					9,605	74,558		
Total Increase [or Decrease]					386	42,442		
Per centage of Increase [or Decrease]					½	6		

BOLT AND ROD.

To	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Australia	19,485	33,247	193,799	295,179	13,762	101,380	...	...
Brazil	...	...	...	...	...	...	...	...
British North America	33,596	48,682	287,677	414,532	15,086	126,855	...	...
East Indies	116,051	114,123	1,016,247	1,016,133	...	...	1,928	114
Egypt	...	...	...	...	...	...	...	...
France	71,344	30,136	617,571	247,028	...	...	41,208	370,543
Hanse Towns	25,656	18,018	253,941	166,608	...	...	7,638	87,333
Holland	15,773	27,511	153,318	240,455	11,738	87,137	...	...
Prussia	...	...	...	...	...	...	...	...
Sardinia	15,385	18,790	131,146	156,587	3,405	25,441	...	...
United States	231,555	221,430	2,027,876	1,917,076	...	...	10,125	110,800
Unenumerated Countries	173,028	209,464	1,535,949	1,803,467	36,436	267,518	...	...
Total in 12 months	701,873	721,401	6,217,524	6,257,065	80,427	608,331	60,899	568,790
Deduct [Increase or] Decrease					60,899	568,790		
Total Increase [or Decrease]					19,528	39,541		
Per centage of Increase [or Decrease]					2¾	⅝		

SHEET, PLATE, AND SUNDRY WROUGHT IRON.

To	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Australia	15,422	19,570	325,419	449,817	4,148	124,398	...	...
Brazil	...	..	...	...	...	...	...	...
British North America	19,793	19,581	265,820	273,280	...	7,460	212	...
Denmark	...	...	...	...	...	...	...	...
East Indies	39,662	29,421	493,557	481,816	...	...	10,241	11,741
France	...	...	...	...	...	...	...	...
Hanse Towns	...	...	...	...	...	...	...	...
Holland	17,503	20,408	236,799	228,438	2,905	...	...	8,361
Russia	...	...	...	...	...	..	..	...
Sardinia	...	...	...	...	...	...	...	...
Spain	...	...	...	...	...	...	...	...
United States	45,714	46,497	577,262	564,631	783	...	...	12,631
Unenumerated Countries	138,165	144,735	1,821,576	1,981,416	6,570	159,840	...	...
Total in 12 months	267,259	280,212	3,720,433	3,979,398	14,406	291,698	10,453	32,733
Deduct [Increase or] Decrease					10,453	32,733		
Total Increase [or Decrease]					3,953	258,965		
Per centage of Increase [or Decrease]					1½	7		

STEAM ENGINES.

To	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. £	Decrease in 1857. £
Australia	54,411	79,786	25,375	...
Brazil	...	...	..	...
British North America	60,449	16,721	...	43,728
Denmark	4,335	19,743	15,408	...
East Indies	61,737	96,169	34,432	...
France	18,612	51,110	32,498	...
Hanse Towns	...	...	...	...
Holland	115,168	32,421	...	82,747
Russia	26,193	67,375	41,182	...
Sardinia	38,109	22,463	...	15,646
Spain	132,459	116,578	...	15,881
United States	...	...	...	...
Unenumerated Countries	307,594	559,920	252,326	...
Total in 12 months	819,067	1,062,286	391,221	158,002
			158,002	
			233,219	
			29½	

SUNDRY MACHINERY.

To	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. £	Decrease in 1857. £
Australia	101,283	106,779	5,496	...
Brazil	...	...	...	...
British North America	...	...	...	...
Denmark	...	...	...	...
East Indies	392,591	463,709	71,118	...
France	158,249	217,045	58,796	...
Hanse Towns	168,768	184,124	15,356	...
Holland	88,308	134,035	45,727	...
Russia	238,524	531,230	292,706	...
Sardinia	...	...	...	...
Spain	141,269	125,508	...	15,761
United States	...	...	...	...
Unenumerated Countries	608,394	1,058,307	449,913	...
Total in 12 months	1,897,386	2,820,737	939,112	15,761

HARDWARE.

To	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Australia	4,232	5,661	408,949	489,932	1,429	80,983	...	...
Brazil	1,541	2,389	125,348	189,104	848	63,756	...	...
British North America	1,937	1,794	182,326	194,369	...	12,043	143	...
Denmark	...	...	...	...	...	...	...	...
East Indies	1,750	2,452	170,495	218,863	702	48,368	...	...
France	601	637	95,856	112,699	36	16,843	..	...
Hanse Towns	2,073	1,985	217,379	216,298	...	...	88	1,801
Holland	...	...	...	...	...	...	...	...
Russia	...	...	...	...	...	...	...	...
Sardinia	...	...	...	...	...	...	...	...
Spain	...	...	...	...	...	...	...	...
United States	8,480	7,284	1,222,419	1,031,867	...	...	1,196	190,552
Unenumerated Countries	14,124	17,048	1,324,826	1,563,195	2,924	238,369		...
Total in 12 months	34,738	39,250	3,747,598	4,016,327	5,939	460,362	1,427	191,633
Deduct [Increase or] Decrease					1,427	191,633		
Total Increase [or Decrease]					4,512	268,729		
Per centage of Increase [or Decrease]					13	7		

EXPORTS OF IRON TO VARIOUS COUNTRIES IN THE YEARS 1856 AND 1857.

WIRE.

To	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Australia	...	...	...	...	...	...	...	...
British North America	...	...	...	...	...	...	...	...
Hanse Towns	..	...	...	...	...	...	..	...
United States	...	...	...	...	...	...	...	...
Unenumerated Countries	9,190	11,443	195,034	243,399	2,253	48,365	...	...
Total in 12 months	9,190	11,443	195,034	243,399	2,253	48,365		
Deduct Increase or Decrease								
Total Increase or Decrease					2,253	48,365		
Per centage of Increase or Decrease					24½	24¾		

STEEL.

To	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Australia	...	...	...	...	...	...	...	...
British North America	...	...	...	...	...	...	...	...
Hanse Towns	...	...	...	...	...	...	...	...
United States	13,719	13,366	462,958	442,240	...	...	353	20,718
Unenumerated Countries	8,139	8,995	272,865	306,141	816	33,276	..	
Total in 12 months	21,858	22,321	735,823	748,381	816	33,276	353	20,718
Deduct Increase or Decrease					353	20,718		
Total Increase or Decrease					463	12,558		
Per centage of Increase or Decrease					2	1¾		

TIN PLATES.

To			Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857.	Increase in 1857. £	Decrease in 1857.	Decrease in 1857. £
Australia	...	...	27,965	36,540	..	8,575	...	...
British North America	...	...	43,776	41,161	...	...	...	2,615
Hanse Towns	...	...	32,760	32,471	...	...	...	289
United States	...	...	1,020,303	961,512	...	...	...	58,791
Unenumerated Countries	...	...	283,102	429,308	...	146,206	...	...
Total in 12 months			1,407,906	1,500,992		154,781		61,695
Deduct Increase or Decrease						61,695		
Total Increase or Decrease						93,806		
Per centage of Increase or Decrease						6½		

TO DENMARK.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Steam Engines	...	...	4,335	19,743	...	15,408	...	...
Sundry Machinery	...	...	...	...	...	...	...	...
Total in 12 months			4,335	19,743		15,408	...	...
Deduct Increase or Decrease								
Total Increase or Decrease						15,408		
Per centage of Increase or Decrease						355		

TO RUSSIA.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Steam Engines	...	...	26,193	67,375	...	41,182	...	...
Sundry Machinery	...	...	238,524	531,230	...	292,706	...	...
Total in 12 months			264,717	598,605	...	333,888	...	...
Deduct Increase or Decrease								
Total Increase or Decrease						333,888		
Per centage of Increase or Decrease						126		

TO SPAIN.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856. £	Declared Value. 1857. £	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Steam Engines	...	...	132,459	116,578	...	...	...	15,881
Sundry Machinery	...	...	141,269	125,508	...	...	...	15,761
Total in 12 months			273,728	242 086	...	...	...	31,642
Deduct Increase or Decrease								
Total Increase or Decrease								31,642
Per centage of Increase or Decrease								11

EXPORTS OF IRON TO VARIOUS COUNTRIES IN THE YEARS 1856 AND 1857.

TO BRAZIL.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £	Decrease in 1857. Tons.	Decrease in 1857. £
Castings	3,992	4,726	£51,612	£61,795	743	10,183	...	...
Rails—Bar, Bolt, and Rod Iron	...	...	...	...	...	...	...	...
Steam Engines	...	...	...	...	...	...	...	...
Hardware	1,541	2,389	125,348	189,104	848	63,756	...	...
Total in 12 months	5,533	7,115	176.960	250.899	1,582	73,939	...	...
Deduct increase or decrease								
Total increase or decrease					1,582	73,939	...	...
Per Centage of increase or decrease					28½	41¾	...	...

TO EGYPT.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Castings	55	833	£917	£12,676	778	11,759	...	...
Rails—Bar, Bolt, and Rod Iron	...	...	...	...	...	...	...	...
Steam Engines	..	...	...	...	...	...	...	...
Hardware	...	...	...	...	...	...	...	...
Total in 12 months	55	833	917	12,676	778	11,759	...	...
Deduct Increase or Decrease								
Total Increase or Decrease					778	11,759	...	...
Per Centage of Increase or Decrease					1,411	1,282	...	...

TO SARDINIA.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Castings	1,870	279	£16,354	£3,829	...	...	1,591	12,525
Rails—Bar, Bolt, and Rod Iron	15,385	18,790	131,146	156,587	3,405	25,441	...	...
Steam Engines	...	...	38,109	22,463	...	...	...	15,646
Hardware	...	...	...	...	...	...	...	...
Total in 12 months	17,155	19,069	185,609	182,879	3,405	25,441	1,591	28,171
Deduct Increase or Decrease					1,591			25,441
Total Increase or Decrease					1,914	...	...	2,730
Per Centage of Increase or Decrease					11	..	...	1½

TO FRANCE.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Pig Iron	84,923	89,401	326,552	333,957	4,478	5,405	...	...
Rails—Bar, Bolt, and Rod Iron	71,344	30,136	617,571	247,028	...	...	41,208	370,543
Sheet, Plate, and Sundry Wrought	...	...	...	...	...	...	...	...
Steam Engines	...	...	18,612	51,110	...	32,498	...	...
Sundry Machinery	...	...	158,249	217,045	...	58,796	...	...
Hardware	601	637	95,856	112,699	36	16,843	...	...
Total in 12 months	156,868	120,174	1,216,840	959,839	4,514	113,542	41,208	370,543
Deduct Increase or Decrease							4,514	113,542
Total Increase or Decrease					...	...	36,694	257,001
Per Centage of Increase or Decrease					...	...	23½	21

TO HOLLAND.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Pig Iron	54,258	83,226	212,021	328,566	28,968	116,545	...	...
Rails—Bar, Bolt, and Rod Iron	15,773	27,511	153,318	240,455	11,738	87,137	...	...
Sheet, Plate, and Sundry Wrought	17,503	20,408	236,799	228,438	2,905	...	...	8,361
Steam Engines	...	...	115,168	32,421	...	...	...	82,747
Sundry Machinery	...	...	88,308	134,035	...	45,727	...	...
Hardware	...	...	...	...	...	...	...	...
Total in 12 months	87,534	131,145	885,614	963,915	43,611	249,409	...	91,108
Deduct Increase or Decrease						91,108		
Total Increase or Decrease					43,611	158,301		
Per Centage of Increase or Decrease					50	19½		

TO PRUSSIA.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Pig Iron	39,296	67,297	151,509	254,733	28,001	103,224	...	...
Rails—Bar, Bolt, and Rod Iron	...	...	...	...	...	...	...	...
Sheet, Plate, and Sundry Wrought	...	...	...	...	...	...	...	...
Steam Engines	...	...	...	...	...	...	...	...
Sundry Machinery	...	...	...	...	...	...	...	...
Hardware	...	...	...	...	...	...	...	...
Total in 12 months	39,296	67,297	151,509	254,733	28,001	103,224	...	..
Deduct Increase or Decrease								
Total Increase or Decrease					28,001	103,224		
Per Centage of Increase or Decrease					73¾	67½		

EXPORTS OF IRON TO VARIOUS COUNTRIES IN THE YEARS 1856 AND 1857.

TO AUSTRALIA.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Castings	15,801	7,787	170,572	108,539	...	...	8,014	62,033
Rails—Bar, Bolt, and Rod Iron	19,485	33,247	193,799	295,179	13,762	101,380	...	...
Sheet, Plate, and sundry Wrought	15,422	19,570	325,419	449,817	4,148	123,498	...	...
Steam Engines	...	...	54,611	79,786	...	25,375	...	...
Sundry Machinery	...	...	101,283	106,779	...	5,496	...	...
Tinned Plates	...	...	27,965	36,540	...	8,575	...	...
Hardware	4,939	5,561	408,949	489,632	1,429	80,983	...	...
Total in 12 months	54,940	66,255	1.282,39[illegible]	1,566,572	19,339	346,207	8,014	62,033
Deduct Increase or Decrease					8,014	62,033		
Total Increase or Decrease					11,325	284,174		
Per centage of Increase or Decrease					22½	22		

TO EAST INDIES.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Castings	16,162	18,421	114,211	151,096	2,259	36,885	...	...
Rails—Bar, Bolt, and Rod Iron	116,051	114,123	1,016,247	1,016,133	...	...	1,928	114
Sheet, Plate, and sundry Wrought	39,662	29,421	493,557	481,816	...	...	10,241	11,741
Steam Engines	...	...	61,737	96,169	...	34,432	...	...
Sundry Machinery	...	...	392,591	463,709	...	71,118	...	...
Tinned Plates	...	...	...	...	...	...	...	...
Hardware	1,750	2,452	170,495	218,863	702	48,368	...	...
Total in 12 months	173,625	164,417	2,248,838	2,427,786	2,961	190,803	12,169	11,855
Deduct Increase or Decrease						11,855	2,961	
Total increase or Decrease						178,948	9,208	
Per centage of Increase or Decrease						8	5½	

TO HANSE TOWNS.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Castings	...	...	...	...	...	...	...	...
Rails—Bar, Bolt, and Rod Iron	25,656	18,018	253,941	166,608	...	...	7,638	87,333
Sheet, Plate, and sundry Wrought	...	...	...	...	...	...	...	...
Steam Engines	...	...	...	...	...	...	...	...
Sundry Machinery	...	...	168,768	184,124	...	15,356	...	...
Tinned Plates	...	...	32,760	32,471	...	...	...	289
Hardware	2,073	1,985	217,379	216,298	...	...	88	1,081
Total in 12 months	27,729	20,003	672,848	599,501		15,356	7,726	88,703
Deduct Increase or Decrease								15,356
Total Increase or Decrease							7,726	73,347
Per centage of Increase or Decrease							28	11

TO BRITISH NORTH AMERICA.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Pig Iron	12,428	15,922	45,886	61,754	3,494	15,868	...	...
Castings	5,293	5,935	38,667	44,168	642	5,501	...	...
Rails—Bar, Bolt, and Rod Iron	33,596	48,682	287,677	414,532	15,086	126,855	...	...
Plate, Sheet, and sundry Wrought	19,793	19,581	265,820	273,780	...	7,460	212	...
Steam Engines	...	...	60,449	16,721	...	...	...	43,728
Sundry Machinery	...	...	...	...	...	...	...	...
Hardware	1,937	1,794	162,326	194,369	...	12,043	143	...
Steel	...	...	...	...	...	...	...	...
Tinned Plates	...	...	43,776	41,161	...	...	...	2,615
Wire	...	...	...	...	...	...	...	...
Total in 12 months	73,047	91,914	924,601	1 045,985	19,222	167,727	355	46,343
Deduct Increase or Decrease					355	46,343		
Total Increase or Decrease					18,867	121,384		
Per centage of Increase or Decrease					25¾	13		

TO UNITED STATES.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Pig Iron	58,500	46,752	228,620	180,953	...	...	11,748	47,667
Castings	835	2,587	22,101	30,855	1,752	8,754	...	...
Rails—Bar, Bolt, and Rod Iron	231,555	221,430	2,027,876	1,917,076	...	...	10,125	110,800
Plate, Sheet, and sundry Wrought	45,714	46,497	577,262	564,631	783	...	...	12,631
Steam Engines	...	...	...	...	...	...	...	...
Sundry Machinery	...	...	...	...	...	...	...	...
Hardware	8,680	7,284	1,222,419	1,031,867	...	...	1,196	190,552
Steel	13,719	13,366	462,958	442,240	...	...	353	20,718
Tinned Plates	...	...	1,020,303	961,512	...	...	...	58,791
Wire	...	...	...	...	...	...	...	...
Total in 12 months	358,803	337,916	5,561,569	5,129,134	2,535	8,754	23,422	661,159
Deduct Increase or Decrease					...		2,535	8,754
Total Increase or Decrease							20,887	432,405
Per centage of Increase or Decrease							5¾	7¾

TO UNENUMERATED COUNTRIES.

	Tons. 1856.	Tons. 1857.	Declared Value. 1856.	Declared Value. 1857.	Increase in 1857. Tons.	Increase in 1857. £.	Decrease in 1857. Tons.	Decrease in 1857. £.
Pig Iron	107,921	120,617	420,530	453,504	12,696	32,976	...	...
Castings	28,386	32,212	297,743	341,661	3,826	43,918	...	...
Rails—Bar, Bolt, and Rod Iron	173,028	209,464	1,535,949	1,803,467	36,436	267,518	...	...
Plate, Sheet, and sundry Wrought	138,165	144,735	1,821,514	1,981,416	6,570	159,840	...	...
Steam Engines	...	...	307,594	559,920	...	252,326	...	...
Sundry Machinery	...	...	608,394	1,058,307	...	449,913	...	...
Hardware	14,124	17,048	1,324,826	1,563,195	2,924	238,369	...	...
Steel	8,139	8,955	272,865	306,141	816	33,276	...	...
Tinned Plates	...	...	283,102	429,308	...	146,206	...	...
Wire	9,190	11,443	195,034	243,399	2,253	48,365	...	...
Total in 12 months	478,953	544,474	7,067,613	8.740,318	65,521	1,672,705		
Deduct Increase or Decrease						...		
Total Increase or Decrease					65,521	1,672,705		
Per centage of Increase or Decrease					23½	27½		

SUMMARY OF TOTAL EXPORTS OF IRON, TO ALL COUNTRIES, IN THE YEARS 1856 AND 1857.

Description.	Tons.		Declared Value.		Equivalent in Pig Iron.		Increase in 1857.	
	1846.	1857.	1856.	1857.	1856.	1857.		
			£.	£.	Tons..	Tons.	Tons.	£.
Pig Iron	357,326	423,215	1,385,118	1,611,467	357,326	423,215	65,889	226,349
Castings	72,394	72,780	712,177	754,619	76,013	76,419	406	42,442
Rails, Bar, Bolt, & Rod Iron	701,873	721,401	6,217,524	6,257,065	935,830	961,868	26,038	39,541
Plates, Sheet, and Sundry Wrought Iron............	276,259	280,212	3,720,433	3,979,398	368,345	373,616	5,271	258,965
Steam Engines	.....	......	819,067	1,062,286	54,604	70,819	16,215	243,219
Sundry Machinery	......	......	1,897,386	2,820,737	94,869	141,036	46,167	923,351
Hardware........................	34,738	39,250	3,747,598	4,016,327	74,952	80,326	5,374	268,729
Steel..............................	21,858	22,321	735,823	748,381	32,787	33,481	694	12,558
Turned Plates.................	......	......	1,407,906	1,500,992	78,217	83,388	5,171	93,086
Wire.............................	9,190	11,433	195,034	243,399	13,785	17,164	3,379	48,365
Total in 12 Months	......	......	20,838,066	22,994,671	2,086,728	2,261,332	174,604	2,156,605
Per Centage of Increase ...							8¼ per cent.	10½ per cent.

EXPORTS OF IRON FOR THE FIRST THREE MONTHS OF THE YEAR 1858.

Description of Iron.	March 31, 1857.	March 31, 1858.	March 31, 1857. Declared Value.	March 31, 1858. Declared Value.	March 31, 1857. Equivalent in Pig Iron.	March 31, 1858. Equivalent in Pig Iron.	March 31, 1858. Increase.	March 31, 1858. Decrease.
	Tons.	Tons.	£.	£	Tons.	Tons.	Tons.	
Pig Iron	71,595	52,609	279,756	164,467	71,595	52,609	......	18,986
Castings	21,780	16,492	200,646	178,714	22,869	17,321	......	5,548
Bar, Bolt, and Rod	165,774	107,370	1,441,767	875,200	221,032	143,160	......	77,872
Wrought, Sundry	56,239	35,930	812,953	560,759	74,985	47,906	......	27,079
Wire	2,718	1,842	51,266	41,658	4,077	2,763	......	1,314
Steel..............................	5,375	2,372	186,002	91,032	8,062	3,558	......	4,504
Tinplates........................	......	......	368,243	223,682	20,515	12,427	......	8,088
Machinery	......	......	434,062	428,499	21,703	21,425	......	278
Steam-Engines	......	......	244,221	231,025	16,281	15,401	......	880
Hardware	8,948	7,168	902,866	679,267	18,057	13,585	......	4,472
			4,921,782 3,474,303	3,474,303	479,176 330,155	330,155	......	149,021
Decrease in 3 Months.........			1,447,479		149,021			
			29¼		31	Per Centage of Decrease.		

NOTE.—The decrease in the Quarter has been chiefly to the United States, viz.:—118,236 Tons out of 149,021, and 25¾ per cent, out of 31 per cent.

will this charge become. If, therefore, capital be recklessly dissipated, it may soon be discovered that the interest, and annual depreciation, will sweep away all profits, because, the number of tons of iron annually made will not bear so heavy an additional charge upon their actual prime cost of manufacture.

Much might be said upon the position of works, but the cheap transit by railway of raw material renders this less a question of importance than formerly; the economical erection of large works is a matter of very serious consideration; the means necessary to produce a required result should be well matured before they are acted upon, and applied with the greatest economy. Careful and circumspect management is imperative in every branch of this manufacture, when we bear in mind that everything which falls short of the standard of economy (by which I mean all the calculations of cost in the manufacture of the iron) is a dead loss. And, whilst I refer to the manager, let me not forget the workman. If this useful portion of our population contribute so largely to the profitable investment of capital, it deserves, and ought to have, a large share of consideration, both from the owners and managers of iron works. We must acknowledge that they perform their work with an intelligence and physical energy equalled by no other nation. Besides the common operations in iron works, a vast amount of skilled labour is continually required; these talented workmen secure to us that manufacturing pre-eminence we enjoy, and it is this union of action, this chain of circumstances, which has raised our staple manufacture to its present state of prosperity. Let, then, our labouring classes be cared for; if they give us their labour with free minds and willing hands, secure to each family a comfortable home; provide the means for a sufficient amount of education to their youth, and of offering up their united thanksgiving to their God. Whilst those exercising authority must at all times maintain their position towards the workmen, and insist upon order and regularity, I feel, because I know from experience, that a master, whilst he acts with firmness and decision, can, and will, command the respect, the unrelaxing duty, and I may also add the attachment of all those who work under his direction;

but such a master, to enable him properly to direct others, must know his business, and he must, in all his acts, make every man feel that he is able to detect the smallest neglect of duty.

When a nation has made rapid strides in any branch of manufacture, it is not surprising to find a natural as well as a laudable desire to follow in the same path. Whilst England may, at present, look round with some security upon the efforts of other countries, do not let us forget that amongst other nations, as well as our own, knowledge daily expands, and will lead them gradually and imperceptibly not only to imitate that perfection which we have attained, but also to add their own improvements. The progressive development of our mineral riches, particularly of our coal and iron, forms a formidable item in the estimate of our national wealth, it increases our importance as a manufacturing people, and strengthens our relative position with other nations, as well as in our own colonies.

Whilst we are engaged in laying down that mysterious link of intelligence with the Western hemisphere, let us not forget our own immediate requirements; we have the power, let us also have the will to bring our Eastern metropolis in direct communication with the rulers of that vast empire at home; let us hope to see her rivers, which everywhere stretch their arms throughout this land, teeming with riches and prolific vegetation, covered with light-draught steam-boats; let railroads open out the immense resources of a country which has successively enriched many European nations, and England's wealth and energy will then draw from this long neglected portion of our empire, those benefits which she ought long ere this to have enjoyed.

DISCUSSION.

Mr. DAVIES said he was particularly struck with the statement made in the paper that from the ordinary samples of Welsh iron, a good metal might be manufactured at a cost of 5s. per ton. All the ordinary processes that they heard of for the manufacture of cheap iron would not come up to that, and he should be glad to find that it was brought extensively into practice. He had frequently heard in that room many excellent theories propounded upon this subject, and he, for one, would be very gratified to see the results of them in practice upon a large scale, but nothing he had heard that evening gave him more pleasure than the statement with regard to the reduced cost of converting pig-iron into steel, which was known to be, at the present time, one of the most expensive processes in which iron manufacturers were engaged. With regard to the question of iron rails, he thought many railway engineers were at fault. Mr. Sanderson had spoken of so many cwts. of pig-iron being required to make a ton of iron rails, but it was to be remarked that a very large quantity of rails were made from that which could scarcely be called iron. Engineers did not always insist upon having the best article, but upon having an article according to the specification which they themselves furnished. Railway tyres were ordered to be of the best quality of iron, but when they came to rails, which he considered to be the most important element in the construction of a railway, a specification was given, based upon theory, as to how the rails should be made. The result of this was that the rails became laminated, making a renewal necessary every three or four years, and creating a liability to accident. It would be found that those lines which were the best constructed as regarded the quality of the materials employed, were the best paying lines. For proof of this, he might mention the North Eastern railway, on which the best quality of rails had been put down, and the result had been, that although the traffic on that line was extremely heavy, yet the expense of maintenance was less than on almost any other line in the kingdom. Engineers often inserted in their specifications that rails should be made "under the hammer," though it was very well known that rails could be made in this way with almost any description of iron. There was an instrument called a "squeezer," which only squeezed the cinder into the metal, without getting rid of it; the squeezer was very inferior to the Nasmyth hammer, which could be so adjusted as to give the lightest or heaviest blows, according to circumstances, and with such an instrument as that, the best rails might be produced. The question of our commerce in iron was an extremely interesting one; and he thought it should be an object with us to show to our continental neighbours that they would be more largely benefited by buying cheap iron of us than by attempting to manufacture it themselves; for where was the labourer in the neighbouring kingdom of France who did not stand in need of a cheap piece of iron? and that could be obtained from this country alone. The present enlightened ruler of France had shown a desire to benefit the people by encouraging the introduction of cheap iron, and we ought not to neglect any opportunity of impressing upon the French people that they had to pay an extra price for their spades and their ploughs and other implements of husbandry, in order to support a monopoly amongst the iron masters of their own country. If our iron trade was extended in proportion to the development of that manufacture, and if continental nations would imitate our example in buying their commodities in the cheapest market, it would enable us to make iron still cheaper, on the principle that a large demand for an article tended to reduce its cost. With regard to America, they must bear in mind that the people of that country voluntarily consented to an iron tax, in order to support certain iron manufacturers at home. They had frequently been told in that room of the vast quantities of coal and ironstone that England possessed; and he might mention one fortunate circumstance, namely, that in South Wales they had coal, and ironstone, and limestone, all of which were ingredients in the manufacture of iron, in closer proximity to each other than, probably, in any other part of the world. These facilities enabled the iron masters of South Wales to hold their own pretty well, even in the present hard times. All the iron masters of England asked for was a clear stage and no favour, and they were prepared to feed the world with iron, which was almost as important an article as bread.

Mr. JOSEPH GLYNN remarked, that in the excellent paper now before them they had been told—not only how much had been done, and what great improvements had taken place in our iron manufactures—but it was shadowed forth that in many respects we were still deficient. It was stated that limestone contained forty per cent. of carbonic acid, and that atmospheric air contained seventy-nine per cent. of nitrogen and twenty-one of oxygen. The quantity of crude material put into the furnace to make a bar of iron was about seven tons of iron-stone, coal, and limestone, and it required three times that weight of atmospheric air to carry on the combustion necessary for the smelting of that mass of materials. It was fortunate, however, that pure air was to be had in plenty merely for the trouble of forcing it into the furnace; but large quantities of mixed gases were thrown off in a state in which they carried away a vast quantity of heat, which heat was in most cases totally wasted. There was a wide field for improvement in that respect. The relative strength of hot and cold blast iron had been touched upon in the paper. That was still a disputed point; but he thought the hot blast produced a material which, like many other things, might be advantageously employed for certain purposes; and at the same time, like high pressure steam and other strong means, it might also be used detrimentally. The hot blast might be used to smelt materials which contained a variety of compounds mingled with the iron; and they must not lose sight of the advantages which had resulted in Scotland from the use of the "black band," as pointed out by Mr. Mushet, and the great wealth that had been derived from the use of that material smelted by the hot

blast. These were points which afforded a wide field for investigation, and were well deserving the attention of ironmasters, opening up as they did a subject of extensive research both for the practical man and the chemist; and he regarded a paper such as that now before them as a great means of contributing to the advancement of this most important branch of our staple manufactures.

Mr. NEWTON, in reference to the remarks that had fallen from Mr. Glynn, as to the waste of the gases thrown off from the blast furnace, said, it had been explained by Mr. Sanderson, that means were now adopted for utilising those products, and the heat arising therefrom. That process had been carried out, to a great extent, at Alsace, where large quantities of iron were manufactured; and it was also in operation at the Ebbw-Vale Iron Works. It had now become generally known: the patent had expired some years, and it could be adopted, with no cost beyond that of the apparatus. He thought, with regard to the process described by Mr. Sanderson, in his paper, that the use of refined metal in the manufacture of iron generally must be advantageous. When this subject of the manufacture of iron and steel was before the Society, on a former occasion, Mr. Sanderson wrote a letter, in which he alluded to this process of his, and he (Mr. Newton) took the liberty of expressing a doubt as to the cost at which it was alleged that bar-iron could be converted into steel. At the same time, he was quite prepared to admit the utility of the process, provided the cost were such as would enable them to produce the material at a reasonable rate. Mr. Sanderson appeared to have taken notice of these observations, and he now stated that he could produce his refined iron at a cost of something like 18s. per ton.

Mr. SANDERSON said, that was the cost of converting bars of iron into steel: the cost of converting the pig-iron into refined iron was a different thing—that was only 5s., per ton. When the iron was made into bar it cost about 18s., to convert it into steel.

Mr. NEWTON apprehended that included waste as well as labour?

Mr. SANDERSON said there was no waste.

Mr. NEWTON remarked that the great point was to get rid of the impurities in the metal. At what cost was that done?

Mr. SANDERSON replied 5s. per ton.

Mr. NEWTON added—If that were so, he apprehended manufacturers would be very glad to employ the process. There was one point which Mr. Sanderson had not alluded to. He had not given them any statistics as to the relative strength of the refined iron as compared with the common iron; because, after all, this was a question which must be decided by figures. The only other point he would allude to, was with respect to some of those new processes of manufacturing steel which Mr. Sanderson appeared to think had not been entirely successful. He (Mr. Newton) would only say that he had seen excellent steel, both bar and sheet, made at the Mersey Iron and Steel Works, under the process described by Mr. Clay, in a paper read before the Society some few weeks since, and as far as he was able to judge, it was a process which was likely to answer well. At the time of his visit to these works, Mr. Clay was making sheet-steel which was to be employed in the construction of ships, and the testing of the plates gave very satisfactory results.

Mr. HOBBS remarked that this was not the first occasion on which he had heard the opinion expressed in that room, that America was not likely ever to become a rival to England in the manufacture of iron. The reason for that was, not that they had not in America sufficient coal, or ore, or limestone, or skilled labour, but because they had not sufficient unskilled labour there, and that he believed, and indeed he hoped, they never would have. If they took the labourer as they found him in the mining districts and transplanted him in America, he would not work underground where people could get land for 5s. an acre, and where they could build their own log cabins and be independent men. That was the reason why America could not compete with England in the manufacture of iron.

Mr. SIEMENS had listened with much pleasure to Mr. Sanderson's elaborate paper, and he had to remark only on one or two points which he thought might lead to misapprehension. Mr. Sanderson stated that 28 cwt. of pig metal produced on an average only 20 cwt. of railway bar, which, in other words, was a loss of 28·6 per cent. of iron; in the processes of puddling and re-heating, in some instances the loss might probably amount to so large a per centage, but at some works with which he (Mr. Siemens) was acquainted, the loss of iron in the puddling furnace did not exceed 12, or occasionally 15 per cent., and a very superior quality of iron was produced without the intermediate process of refining being resorted to. In the course of the last twelve months he (Mr. Siemens) had been engaged upon experiments in the manufacture of iron and steel, and his observations went to prove that the loss of iron sustained in the puddling and re-heating furnaces must be attributed chiefly to the oxidizing action of the flame, which in striking against the iron converted it into slag; by the process which he had adopted (and which had been alluded to lately at this Society, on the occasion of Mr. Clay's paper), he had practically succeeded in reducing the loss sustained in the puddling of crude pig iron to 5 per cent. only, besides which he had obtained other important results, which he expected to bring shortly before the public, but which he would not enlarge upon on the present occasion. He agreed with Mr. Sanderson that not much advantage could be obtained by the use of many of the new plans of converting iron into steel which had of late been proposed, because the actual process of conversion constituted but a very small proportion in the cost of cast steel. The chief expense was incurred in melting the converted steel, the trade price for which was £10 per ton; and improvements should, he thought, chiefly be directed to this point; for machinery purposes the puddled steel by Riepe's process would probably be extensively used, because it was the only known method of producing steel in large masses without necessitating the process of melting.

Mr. HOWELL had listened with great interest to the description given in the paper of the plan of combining iron and steel so as to secure the greater resisting body of the latter in connection with the tenacious quality of the former. He produced to the meeting a specimen of his homogeneous metal, which, he said, was perfectly malleable and possessed all the strength of fused metal, but was free from lamination, combining perfect ductility with the greatest tensile strength. This was a malleable iron, fused in pots and melted in masses sufficiently large for the manufacture of blocks and sheets from one ton to ten tons each in weight, and these were in all respects as sound and as regular as the specimen he now exhibited. The tensile strength of this metal was to be depended upon up to 50 tons per square inch, and when punched there was no liability to shatter. It was in fact cast steel, but without its brittleness. It was pure iron as nearly as it could be made, means being employed to free it from the impurities which were known to exist in bar iron. Mr. Howell mentioned several of the uses to which this homogeneous metal had been applied; amongst others, for multitubular boilers, coupling chains, &c. The little steam-vessel taken out with the expedition of Dr. Livingstone was constructed of this material, the plates being only one-tenth of an inch in thickness, and these were found to be stronger than the ordinary one-eighth plates used in ship building. In reply to an inquiry, Mr. Howell added that the cost of this metal was £50 per ton, but from so much less weight being necessary, the expense was not much greater than that of the ordinary plates.

Mr. ANDERSON expressed his obligations to Mr. Sanderson for his valuable paper, and would refer to one or to points in which he felt an interest. One was the comparative merits of hot and cold blast iron. On the

point of strength, he believed it had been proved that both descriptions were pretty nearly equal, and therefore he thought the question did not so much depend upon the nature of the blast as upon the quality of the ore and fuel. Mr. Sanderson had stated that the strength of iron was in proportion to its freedom from earthy matters, from which it would be inferred that he meant that iron of the greatest specific gravity possessed the greatest tenacity. The experiments which had been made did not bear out this view. Reference had been made to the probability of making effective ordnance with wrought iron. Although one splendid specimen of manufacture of that description had been made at the Mersey works, under Mr. Clay, yet he did not think much was to be said as to the likelihood of wrought iron ordnance being employed to any extent. An immense effort had been made to manufacture wrought-iron plates of great thickness, for the purpose of floating batteries, so as to render them shot and shell proof; but, although plates had been turned out 8 or 9 inches thick, yet they failed to afford effectual resistance to these missiles. He thought they might look with some hope to the metal introduced by Mr. Howell as affording a valuable material for ordnance; or to some combination of pure iron with carbon, so as to get a material that could be cast in a mass suitable for cannon. Mr. Anderson expressed a high opinion of the value of Mr. Howell's homogeneous metal, for machinery that was intended for exportation to long distances, and where a large amount of wear and tear was expected. This, he said, had been exemplified in the case of some boilers sent to Russia. He begged to express his cordial concurrence with the concluding remarks of the paper as to the interest which employers ought to feel in the social condition of those in their service; and he believed that any measures in that direction benefited the employer and the employed.

Mr. PEARSALL thought Mr. Sanderson had remarked upon the utilisation of the heat from the blast furnaces in a disparaging tone, yet science had fully proved, and practice had shown, that 80 per cent. of the heat was not employed in the conversion of the iron. It had been stated that at the Ebbw Vale works plans for rendering this surplus heat available were in constant operation. Why, then, were they not more generally adopted? It was true that there were circumstances which threw difficulties in the way. He himself had witnessed a fearful explosion, which had resulted from an attempt to carry out this system in large ironworks, and it was not surprising that this had excited considerable prejudice, though, by judicious management, such accidents might no doubt be avoided.

Mr. WINKWORTH rose to ask, whether "iron and steel united in a bloom, and subsequently rolled to a sheet," and otherwise prepared for the purpose, as explained in the paper, had ever been introduced in ship-building, tubular bridges, or in the construction of railways. If, from the superior quality of the material so prepared, the quantity required for a given purpose was less than that of the article generally used, the higher price of the materials might be thus neutralized. He had also to congratulate Mr. Sanderson on the clear economical views with which he had closed his very interesting paper. It was surprising that a country, so intelligent generally as France, should still adhere to a policy so suicidal as that of protection—falsely so called. It was well known that the Emperor was friendly to freedom of commercial intercourse, and his hands would be largely strengthened, if, instead of criticising modes of government, with which the people of France only were concerned, we addressed ourselves to the propagation, especially amongst the workpeople, of those principles of international mercantile policy, which would afford, in their development, the largest material comfort.

Mr. HOBBS remarked in reference to the subject of free trade, that he had recently imported machinery from the United States into England, upon which he had had to pay a duty of 10 per cent.

Mr. DAVIES added, in reply to the remarks of Mr. Pearsall, that in South Wales many establishments would be found where the utilisation of the gases from the furnace was carried out. In many works they would not see such a thing as a fire under the boiler, the steam being generated by the gas utilised from the blast furnaces.

The CHAIRMAN, in proposing a vote of thanks to Mr. Sanderson for his paper, said the interest and value of the paper had been increased by the discussion to which it had given rise, for he thought they would agree that this had been of an interesting and useful character. He could not allow the proceedings to close without briefly alluding to the enormous growth of this great interest in this country. He had no doubt all who heard him were aware that up to the close of the last century England imported rather than exported iron and most other materials, and yet they had heard that during the last year the exports of manufactured iron amounted to the enormous sum of twenty-two millions sterling, an amount second only to the gigantic cotton exports; and when they remembered that this had all been brought about within the short period of half a century, they felt wonder and amazement at the progress of the country; and they could only hope that if these gigantic interests were conducted with a due regard to the well-being of the great masses of the people, no evil consequences would result. It was marvellous to trace not simply the gigantic growth of the iron trade, but also to note the changes which, from time to time had taken place in the seat of that manufacture. It was a fact, known to many present, that the iron railing around St. Paul's Cathedral was manufactured within 25 miles of London, on the confines of Kent and Sussex; and that iron formed, for two or three generations, the staple manufacture of those counties. It was a curious fact, to which their attention had been directed by Mr. Davies, that those materials which were most suited to be used together, were frequently found in close proximity to each other. The ironstone, the coal, and the limestone, were all found at the same spot. With reference to the methods adopted in the manufacture of iron, he might remark that it was not until the seventeenth century that coal was used in this country to any great extent in the melting of iron ore, and it was only in the beginning of the last century that it came to be extensively used for that purpose in the iron works of Shropshire. The great value of the paper consisted, he thought, in its having directed their attention to the application of science to the iron trade, which seemed to be the only means whereby we could maintain the supremacy we had obtained over every other country in the production and manufacture of iron; and in the commercial struggle that took place between different nations, it was all important that we should take advantage of the appliances we possessed, and avail ourselves of those considerations to which Mr. Sanderson and other writers on this subject had directed attention.

A vote of thanks was then passed to Mr. Sanderson.

Mr. SANDERSON, in reply, said, Mr. Davies had referred to the refined metal, and remarked that if it could be produced for five shillings per ton with so small a waste in the puddling furnace, it would be a great advantage to the trade. He (Mr. Sanderson) would give the particulars of the cost of the manufacture, showing that its cost would not, where the metal was drawn from the blast furnace, exceed five shillings per ton. The fluid metal was drawn from the blast furnace into the refinery, which was simply a receptacle heated not higher than that of the ordinary puddling furnace. Any reagent which on its decomposition gave out oxygen, was added, which, combining with the carbon eliminated from the iron, formed carbonic oxide. This immediately reduced all the metalloids and unreduced matter, entirely liberating all deleterious matter contained in the iron, thereby producing a highly decarbonized,

clean, crystallized metal. He observed that, when this metal, produced at so low a cost, was used in the puddling furnace, malleable iron was turned out, of a very superior quality and with an extremely small waste, thereby effecting a considerable economy to the iron maker, and raising the standard quality of his finished materials. Mr. Davies had observed that, owing to the orders which engineers give for rails, the makers were compelled to manufacture them of an extremely low quality, adding, that they were not iron, but a miscellaneous compound. In this Mr. Sanderson fully agreed, and that squeezers were the worst things which could be used in a work where quality was looked for. He quite agreed in the advocacy of using better rails, and thought it would be to the advantage of other companies besides the North Eastern to lay down a superior quality of rails, which, although expensive at first, were economical in the end. With regard to the objection which had been raised to the utilization of the gases, he stated that danger might arise from want of proper attention to the apparatus, thereby subjecting the gases to explosion, just as much as a steam-boiler would explode, if allowed to become dry. With reference to Mr. Howell's remarks, he (Mr. Sanderson) fully concurred in the excellence of that gentleman's metal, and compared it with his (Mr. Sanderson's) metal, which was a compound of iron and steel, the latter being so much cheaper an article that it could be made useful for many engineering purposes for which Mr. Howell's metal would be too expensive. Mr. Sanderson said that there were still observations (Mr. Siemens', Mr. Winkworth's, Mr. Hobbs', and others) to which he should have liked to reply, but the lateness of the hour prevented him from so doing, and he concluded by thanking the meeting for the attention which they had given to his paper.

The Secretary announced that on Wednesday evening next, the 12th inst, a Paper by Professor John Wilson, on "Canada: its Productions and Resources," would be read.

The following letter has been received by the Secretary since the meeting:—

SIR,—Mr. Sanderson, in his paper, has brought forward a proposition for the employment of a light combined steel and iron rail, which is of great importance if it can be carried into effect. Up to this time the progress of railways in India has been withheld by the Indian authorities, on the ground that the amount of shipping available for the cheap freight of rails is only sufficient to allow of the prosecution of the main lines of railway without causing a very great rise in freights, and thereby in the cost of the railways. On this ground sanction is refused to many valuable trunk and branch lines, the prosecution of which would be of the greatest value to India. If, therefore, a rail could be laid down of equal strength, but of half the weight, the consequence will be that the present amount of freight to India will be adequate for the supply of rails for double the length of line now in process of execution.

I am, &c., HYDE CLARKE.

Northern Bengal Railway, 42, Basinghall-street,
6th May, 1858.

SOUTH KENSINGTON MUSEUM.

During the week ending 1st May, 1858, the visitors have been as follows:—On Monday, Tuesday, and Saturday (free days), 4,591; on Monday and Tuesday (free evenings), 4,353. On the three Students' days (admission to the public 6d.), 1,199; one Students' evening, Wednesday, 173. Total, 10,316.

Proceedings of Institutions.

BEDFORD.—The twelfth annual meeting of the Literary and Scientific Institution was recently held in the reading-room, William Blower, Esq., vice-president, in the chair, who, after a brief introductory speech, called on Mr. Coombs, the hon. secretary, to read the report. The treasurer's account showed that, during the past year, the income had amounted to £86 10s. 7d.; the expenditure, for the same period, to £83 12s. 5d.; leaving a balance in the treasurer's hands of £2 18s. 2d. Notwithstanding that several other Institutions with similar aims and objects have been formed, the committee report considerable additions to the library, which now contains upwards of 2,000 well-selected volumes of the best writings in the various departments of science and general literature. Lectures have been delivered by Dr. Letheby (in continuation of his former lecture on "Chemical Magic,") and by George Dawson, Esq., M.A., on "The Origin, Character, and Doings of the Anglo-Saxons." Communications have been received from the Council of the Society of Arts, in reference to the Examinations for the Prizes and Certificates of the Society, and it has been suggested to the committee that a Local Board of Examiners be appointed in Bedford to act for the district of which it is the centre. The best attention of the committee will be given to this subject, and the fullest information thereon communicated in due course to the members. The vice-presidents, treasurers, secretary, librarian, auditors, and the four retiring members of the committee, were unanimously re-elected. The formation of a Local Board of Examiners for conducting the "previous Examination" of the Society of Arts for its Prizes and Certificates, as referred to in the report, was considered. A discussion ensued on the merits of the proposed Examinations, Prizes, and Certificates, and of the value of the Institution's connection with the Society of Arts, when it was resolved—"That a Local Board of Examiners be formed in accordance with the plan of the Society of Arts."

BIRMINGHAM.—A valuable collection of recent shells, British and foreign, has been presented to the Midland Institute, by Mrs. Taylor, late of Moseley Hall. They are well arranged and in excellent condition, and will form an important addition to the existing collection.

MEETINGS FOR THE ENSUING WEEK.

MON. ......Geographical, 8½. I. Mr. James S. Wilson, "Notes on his Journey in North-west Australia." (Communicated by Sir Roderick Murchison.) II. Dr. H. Barth, "General Historical View of the State of Human Society in Northern Central Africa."

TUES. ......Royal Inst., 3. Mr. J. P. Lacaita, "On the History of Italy during the Middle Ages."
Syro-Egyptian, 7½. Mr. Sharpe, "On the Gnostic Gems and Opinions of the second century of our Era."
Civil Engineers, 8. Mr. A. Giles, M. Inst. C.E., "On the Construction of the Southampton Docks."
Med. and Chirurg., 8½.
Zoological, 9.

WED. ......Literary Fund, 3.
Society of Arts, 8. Prof. John Wilson, "On Canada: its Productions and Resources."
Geological, 8. I. Mr. G. Poulett Scrope, "On Lamination and Cleavage, caused by the Mutual Friction of the Particles of Rocks while in Irregular Motion." II. Prof. Harkness, "On Jointings, and on the Dolomites of Cork."
Graphic, 8.
Archæological Asso., 8.

THURS. ...Antiquaries, 8.

FRI. ....United Service Inst., 3. Major Griffiths, "On Field Fortification."
Royal Inst., 8½. Mr. Henry Bradbury, "On Printing: its Dawn, Day, and Destiny."

SAT. ....Asiatic, 2. Anniversary.
Royal Inst., 3. Dr. Lankester, "On the Vegetable Kingdom in its relations to the life of man."
Medical, 8.

PATENT LAW AMENDMENT ACT.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette, April* 30, 1858.]

Dated 21st December, 1857.

3126. J. H. Nosworthy, London—An improved apparatus for exhibiting cards, bills, and other like advertisements.

Dated 6th February, 1858.

220. L. F. Candelot, 16, Rue St. Quentin, Paris—Divers anti-nitrous cements, also applicable to rendering damp surfaces impervious, and to flagging and similar purposes.

Dated 9th February, 1828.

241. G. Pringle, Prestonpans, N.B.—Imp. in machinery or apparatus for propelling ships or vessels.

Dated 9th March, 1858.

476. H. Deacon, Widnes, Lancashire—Imp. in purifying alkaline lees.

Dated 10th March, 1858.

486. J. F. Gee, Wrexham—Imp. in the joining of earthenware pipes for drains, sewers, and telegram wire conductors, also suitable for the conveyance of liquids, gas, and steam under pressure, when jointed.

Dated 11th March, 1858.

495. F. E. D. Hast, Aldermanbury—An improved mode of manufacturing stearine. (A com.)

Dated 23rd March, 1858.

608. E. Peters, Grimsby—Imp. in burning bricks and other articles, made of brick earth and clay. (A com.)

Dated 26th March, 1858.

644. J. J. T. Schlœsing, 22, Rue d'Austerlitz, and E. Rolland, 21, Rue de Bellechasse, Paris—Imp. in the manufacture of carbonates of soda.

Dated 27th March, 1858.

656. F. Bousfield, 20, Hereford-terrace, De Beauvoir-road, Kingsland—Imp. in apparatus to facilitate the production of duplicate writings.

Dated 7th April, 1858.

740. E. P. Sibille, 11, Conduit-street, Regent-street—A new apparatus for warming or cooling atmospheric air, water, and all liquids of a similar density to it, warming them to the degree of heat necessary for their transformation into steam.

Dated 9th April, 1858.

762. T. Greenwood and J. Batley, Leeds—Imp. in machinery for heckling flax and other fibrous materials.

764. R. McCafferty, Lancaster, U.S.—Preventing incrustation in steam boilers.

766. G. Smith, 21, Wichampton-street—Imp. in the manufacture of close stools, night commodes, and water closets.

770. H. Bauerrichter and C. G. Gottgetreu, Charterhouse-square—Imp. in printing gold, silver, bronze, and other metal, on glass.

Dated 10th April, 1858.

772. A. Lees, Soho Iron Works, Oldham, and D. Schofield, Oldham—Imp. in the construction of carriages for certain machines used in spinning and doubling.

774. A. Neumann, London—An improved strop for sharpening razors, knives, or other edged instruments.

778. F. A. Lecornu, Paris—Imp. in drawing and levelling instruments.

780. J. Pouncy, High West-street, Dorchester—Imp. in the production of photographic pictures.

782. W. Rowett, Netherfield-road, Liverpool—Imp. in the construction of electric telegraph cables or ropes.

784. J. Rae, Blackwall—Imp. in the construction of iron ships.

Dated 12th April, 1858.

789. T. Kay, Oxenhope, near Keighley, Yorkshire—An improved method of producing or obtaining heat suitable for the singeing of yarns and textile fabrics, which heat is also applicable to other heating purposes.

791. P. Ratel, Paris—A new or improved machine for depositing grain and manure.

Dated 13th April, 1858.

793. T. Spiller, 5, Red Lion-square—Exhibiting slides in the stereoscope, and preserving them from injury, to enable each slide to be conveyed to the point of view, and then after use deposit them each in its place in the box, without handling or exposing the slides to the chance of being soiled, keeping them always under cover in safety; a box 18 in. by 8 in. square will hold and exhibit near 1000 slides.

795. T. T. Jopling, Dunning-street, Bishopwearmouth—Imp. in waterclosets.

797. P. Schafer and F. Schafer, Brewer street—Imp. in fastenings for travelling bags, portmanteaus, and other like articles.

799. T. B. Ayshford, 1, Britannia-road, Walham-green, Fulham—Certain imp. in the construction of carriages called omnibuses.

Dated 14th April, 1858.

801. R. Armstrong, North Woolwich, and J. Galloway, Manchester—Imp. in apparatus and furnaces for heating, welding, or melting metals, parts of which improvements are applicable to other furnaces.

803. W. C. Holmes and W. Hollingshead, Huddersfield—Imp. in the manufacture of metal castings.

805. M. A. F. Mennons, 39, Rue de l'Echiquier, Paris—Certain imp. in voltaic batteries. (A com.)

807. T. Osborne and R. A. Bell, Derby—An apparatus for suddenly detaching railway carriages or waggons.

809. C. Mather, Salford Iron Works, Salford, and H. Charlton, Blackfriars-street, Manchester—Imp. in apparatus for drying cotton, linen, wool, yarn, seed, and other articles.

811. J. H. Johnson, 47, Lincoln's-inn-fields—Imp. in sawing machines. (A com.)

813. A. F. Newton, 66, Chancery-lane—Imp. in rotary pumps. (A com.)

Dated 15th April, 1858.

815. F. Preston and W. McGregor, Manchester—Imp. in machinery for forging and cutting files.

817. L. Cowell, Adelphi—An instrument or nippers for cutting the wired, corded, or like fastenings of corked bottles.

819. W. Spence, 50, Chancery-lane—Imp. in the pedestals and journal boxes of railway carriages. (A com.)

821. J. Harris, Woodside, and T. Summerson, Haughton-le-Skerne, near Darlington—An imp. in railway chairs.

Dated 16th April. 1858.

823. J. Boot, Manchester—Imp. in machinery or apparatus for making labels.

825. P. Brotherhood, Chippenham—Imp. in the construction of locomotive and other steam boilers.

827. G. Walker, Edgbaston, Warwickshire—An improved union apparatus for cleaning and polishing knives and forks, and boots and shoes, and which said apparatus is also applicable for sharpening knives and sharpening or cleaning other articles.

829. A. P. Price, Margate—Imp. in obtaining cadmium, and certain compounds thereof.

831. J. H. Johnson, 47, Lincoln's-inn-fields—Imp. in preparing printing surfaces. (A com.)

Dated 17th April, 1858.

833. E. F. Sans, Epernay (Marne), France—Apparatus serving to mesure upon a large scale the smallest pressions of any fluid matters.

835. A. A. Lutereau, Paris—The purpose, by machinery, to polish wholly or partly leather paper-hanging, and all other febril stuff, that is to say, that a piece can be polished in several parts, having spaces unpolished.

837. D. Chalmers and J. T. Swallow, Manchester—Imp. in looms.

839. J. R. Chirm, junr., Birmingham—A new or improved chimney pot or top.

845. J. H. Johnson, 47, Lincoln's-inn-fields—Imp. in sewing machines. (A com.)

847. W. Latham, Russell-court, Drury-lane—Imp. in the manufacture of hats and caps.

Dated 19th April, 1858.

849. M. B. Westhead and H. Baines, Manchester—Certain imp. in machinery or apparatus for the prevention of accidents, applicable to hoisting and other lifting machines employed in connection with railways or other places where heavy bodies require to be moved from one level to another.

851. W. H. Ridgway, East View-place, Hanley, Staffordshire—Improved apparatus for opening the covers of jugs.

853. J. Howorth, Farnworth—Improved apparatus to facilitate the discharge of smoke and prevent its return, which said apparatus is also applicable for the ventilation of buildings.

855. M. Henry, 77, Fleet-street—Imp. in the manufacture of candles, and in preparing materials for the same, and in apparatus employed therein. (A com.)

857. E. K. Calver, Sunderland—Imp. in the formation of harbours of refuge, which improvements are also applicable as a wave screen in other situations.

859. W. Clark, 53, Chancery-lane—A new instrument for taking the altitude of the sun, to be termed the "Helypsometer." (A com.)

WEEKLY LIST OF PATENTS SEALED.

30th April.

2758. W. Shields.
2760. J. Davy and W. Bentley.
2764. M. Stodart.
2784. J. Apperly & W. Clissold.
2788. J. Mallison, junr.
2793. R. Wappenstein.
2796. J. Seithen.
2805. J. Miller.
2906. G. R. and D. C. Simpson.
2810. H. Beinhauer.
2814. H. R. Palmer.
2817. G. Canouil.
2824. J. Adams.
2834. W. J. Elwin.
2844. H. and S. Thompson.
2868. M. Henry.
2908. D. Melvin.
3045. C. Westendarp, junr.
3196. P. W. Barlow.
122. W. Weild.
437. W. Thomson.

4th May.

2816. R. K. Aitchison.
2821. H. Baines.
2822. J. Fordred.
2842. J. Harrington.
2848. I. Taylor.
2856. W. Picking.
2265. G. J. Bensen.
2977. C. Goodyear.
3098. J. J. Davis.
3200. J. Long.
18. G. E Dering.
135. G. E. Dering.
351. W. McLennan.
416. W. H. Sleeboom.
507. L. F. Corbelli.

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

April 26th.

1133. F. W. Mowbray.

April 27th.

962. W. E. Carrett.
963. J. Marsh.
970. P. Dépierre.

April 28th.

984. F. W. Harrold.
998. J. Lacassagne & R. Thiers.

April 29th.

975. W. Hartley.
986. H. Lee, junr., & J. Gilbert.

April 30th.

969. H. Francis.
979. W. Banks, H. Hampson, and J. Banks.

May 1st.

988. M. A. C. Mellier.